INSTRUCTION MANUAL

TRACE ENTERPRISES
NEW AND USED TEST EQUIPMENT SALES AND SERVICE

microwave amplifier

560A SERIES

Model 560A Serial 457

Copyright ALFRED ELECTRONICS 1969

ALFRED ELECTRONICS • STANFORD INDUSTRIAL PARK • PALO ALTO, CALIFORNIA

TELEPHONE: 326-6496 • TWX: 910-373-1765

TABLE OF CONTENTS

Page No.

Section 1 INTRODUCTION

1.1 Specifications 1-1
1.2 Description 1-2

Section 2 OPERATING INSTRUCTIONS

2.1 Front Panel Controls 2-2
2.2 Operating Procedures 2-2
2.3 Power Requirements 2-2

Section 3 CIRCUIT DESCRIPTION

3.1 The Traveling Wave Tube 3-1
3.2 Power Supplies 3-1
3.2.1 The -20 and -70 Volt Power Supplies (Low Voltage) 3-1
3.2.2 The Heater and High Voltage Supplies 3-1
3.2.3 The Anode Supply 3-2

Section 4 MAINTENANCE

4.1 Periodic Maintenance 4-1
4.2 Voltage Measurements At Chassis Test Points 4-1
4.3 Trouble Shooting 4-5
4.4 Internal Adjustments 4-5
4.5 Replacement of the TWT 4-6
4.6 Performance Check 4-10

Section 5 PARTS LIST

560A/561A Parts List 5-1
562A/563A Parts List 5-4
List of FSC Codes for True Manufacturers 5-7

Section 6 SCHEMATICS

Schematics are included in the following order:

900682C - Low Voltage Power Supplies
900683C - Heater & High Voltage Supplies
900778C - High Voltage Anode Supply (560A & 561A)
900864C - Low Voltage Anode Supply (562A & 563A)
900777D - TWT Amplifier Main Chassis (560A & 561A)
900779D - TWT Amplifier Main Chassis (561A & 562A)

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_05222

SECTION 1 — INTRODUCTION

1.1 SPECIFICATIONS

Frequency Range:	Model 560A, 1 - 2 Gc Model 561A, 2 - 4 Gc Model 562A, 4 - 8 Gc Model 563A, 7 - 12.4 Gc
Power Output:	1 watt minimum.
Gain:	Small signal, 30 db minimum. At rated power, 30 db minimum.
RF Impedance:	50 ohms.
RF Connectors:	Type N Female.
Gain Adjustment:	Front panel control provides a 50 db control range.
Gain Variation with Line Voltage Variation:	0.2 db or less at 1 watt output with a line voltage variation of 105 to 125 volts.
Maximum Mismatch for Rated Power Out:	1.5:1
For No Tube Damage:	5 : 1
Modulation:	GRID MOD INPUT connector coupled to ANODE of TWT. With the GAIN control set to no cathode current, a 0 to +10 volt signal turns cathode current of TWT to maximum. With the GAIN control set to maximum cathode current, a 0 to -10 volt signal turns cathode current of TWT off. Input impedance; 10 K Ω.
RF Rise Time:	Models 560A and 561A less than 4 μsec. Models 562A and 563A less than 2 μsec.
Spurious Modulation:	At least 45 db below output signal level.
Time Delay:	Automatic 90 second time delay before application of high voltage.

Metering:	Cathode current by front panel meter.
Power Supply:	All electrode voltages are regulated. Protective relays turn off traveling wave tube power on helix overcurrent.
Power Input:	105 to 125 volts or 210 to 250 volts; 50/60 cycles/second; approximately 250 voltamperes.
Physical:	See Figure 1-1.
Weight:	Less than 43 pounds.

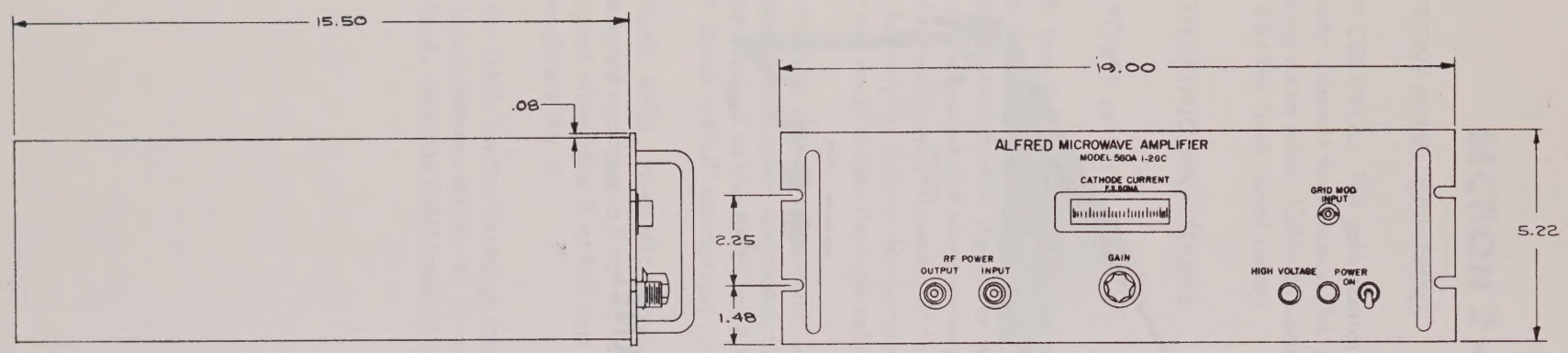
1.2 DESCRIPTION

The ALFRED 560A Series Microwave Amplifiers are amplifiers and modulators of microwave signals in the frequency range of 1 to 12.4 Gc. They are high gain (30 db) instruments utilizing a traveling wave tube powered by low drift, low ripple, precisely regulated transistorized power supplies.

The anode (positive grid) of the traveling wave tube is coupled to the GRID MOD INPUT jack. Modulation of the rf can be accomplished by either a 0 to +10 volt or a 0 to -10 volt signal applied through the connector. The front panel gain control varies the traveling wave tube cathode current over a 50 db range.

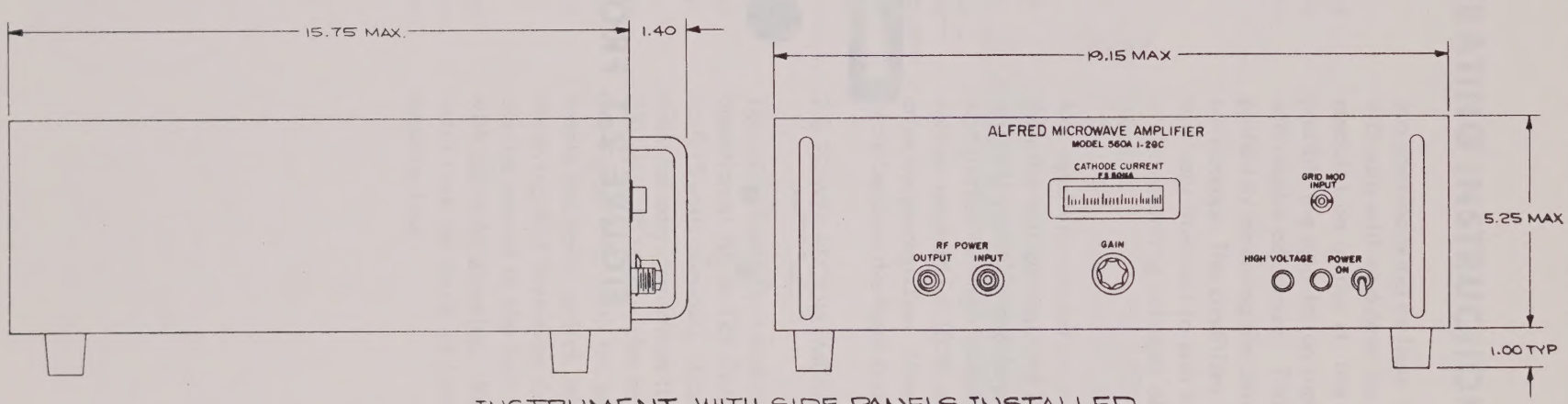
The traveling wave tube does not require rf adjustment, is encapsulated for protection and is easily replaced. A front panel meter monitors cathode current. Protective circuits reduce the likelihood of damage to the tube.

SYM	DESCRIPTION	NO.	DATE	BY



INSTRUMENT WITH SIDE PANELS REMOVED

(FOR RACK MOUNTING)



INSTRUMENT WITH SIDE PANELS INSTALLED

NOTES:

1. THE MODEL 560A SERIES INSTRUMENT MAY BE EITHER BENCH MOUNTED OR RACK MOUNTED.
2. FOR RACK MOUNTING, REMOVE BOTH SIDE PANELS.
3. WEIGHT OF INSTRUMENT IS LESS THAN 43 POUNDS.

FIGURE 1-1

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL		
MATERIAL STOCK NO.		
FINISH OR TREATMENT		

DRAWN	Dave Presley	9-2-64
ENG	Y. Oshima	9-4-64
PROD		

SCALE 1:2

OUTLINE & DIMENSIONAL DATA FOR MODEL 560A SERIES INSTRUMENT

DIMENSIONS ARE IN INCHES
TOL: XX ± .015 XXX ± .005 ANGLE ± ½°
UNLESS INDICATED OTHERWISE

NEXT ASSY	USED ON
	560A SERIES

ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

990131C

SHEET 1 OF 1

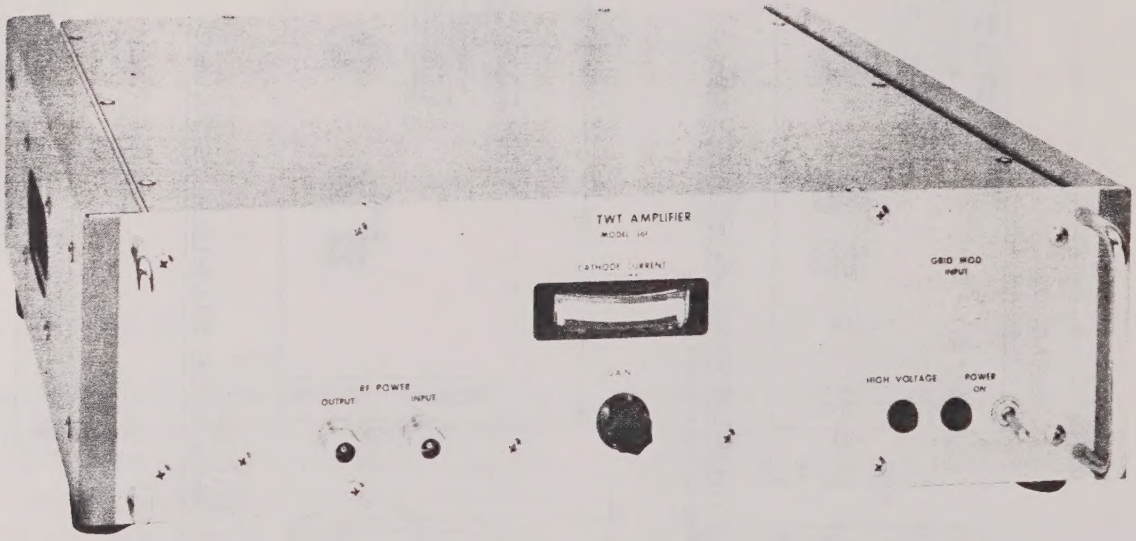


FIGURE 2-1. FRONT PANEL

SECTION 2 — OPERATING INSTRUCTIONS

2.1 FRONT PANEL CONTROLS

GAIN CONTROL: The gain control adjusts the cathode current and hence the gain of the traveling wave tube. Cathode current is monitored by the front panel meter.

2.2 OPERATING PROCEDURES

Turn POWER switch to ON.

NOTE: Time delay relays used in the Model 560A Series delay high voltage turn-on for approximately 90 seconds after the power is turned on. This is to allow a brief warm-up period for the traveling wave tube filament. If the ac power is off for only an instant, the normal 90 second delay will occur before the high voltage returns.

After the high voltage appears the unit is ready for operation. Rf power and modulation voltages can be applied to the RF POWER INPUT and GRID MOD INPUT connectors respectively.

The Model 560A Series Microwave Amplifiers are designed to accept a 0 to -10 volt modulation signal although a 0 to +10 volt signal will also modulate the rf.

With the GAIN control turned up (clockwise) an input signal between 0 and -10 volts will modulate the rf. With the GAIN control turned down (counterclockwise) an input signal between 0 and +10 volts will modulate the rf. To obtain 100% modulation of the rf, the GAIN control and possibly the modulation input signal amplitude will require adjustment. This can best be accomplished by observing the detected rf signal on an oscilloscope. The conditions for 100% modulation will vary from unit to unit because of variations in the operating voltages of the traveling wave tubes.

Any applied modulation voltage which is less than the voltage required for 100% modulation will only partially modulate the rf. Any applied modulation voltage which is greater than the voltage required for 100% modulation will overdrive the preamplifier. However, no damage will occur because the input is adequately protected.

2.3 POWER REQUIREMENTS

The unit is normally connected at the factory for operation at 105 to 125 volts and 50 to 60 cycles ac (115 volts nominal). However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 60 cycles ac (230 volts nominal). See Figure 4-2. With the bottom cover removed locate the power switch labeled 115 VAC. By removing and reversing this plate, the switch can be moved to the left. Replace the plate with 230 VAC showing. Replace the 3 ampere main fuse (in back of instrument) with a 1.5 ampere fuse.

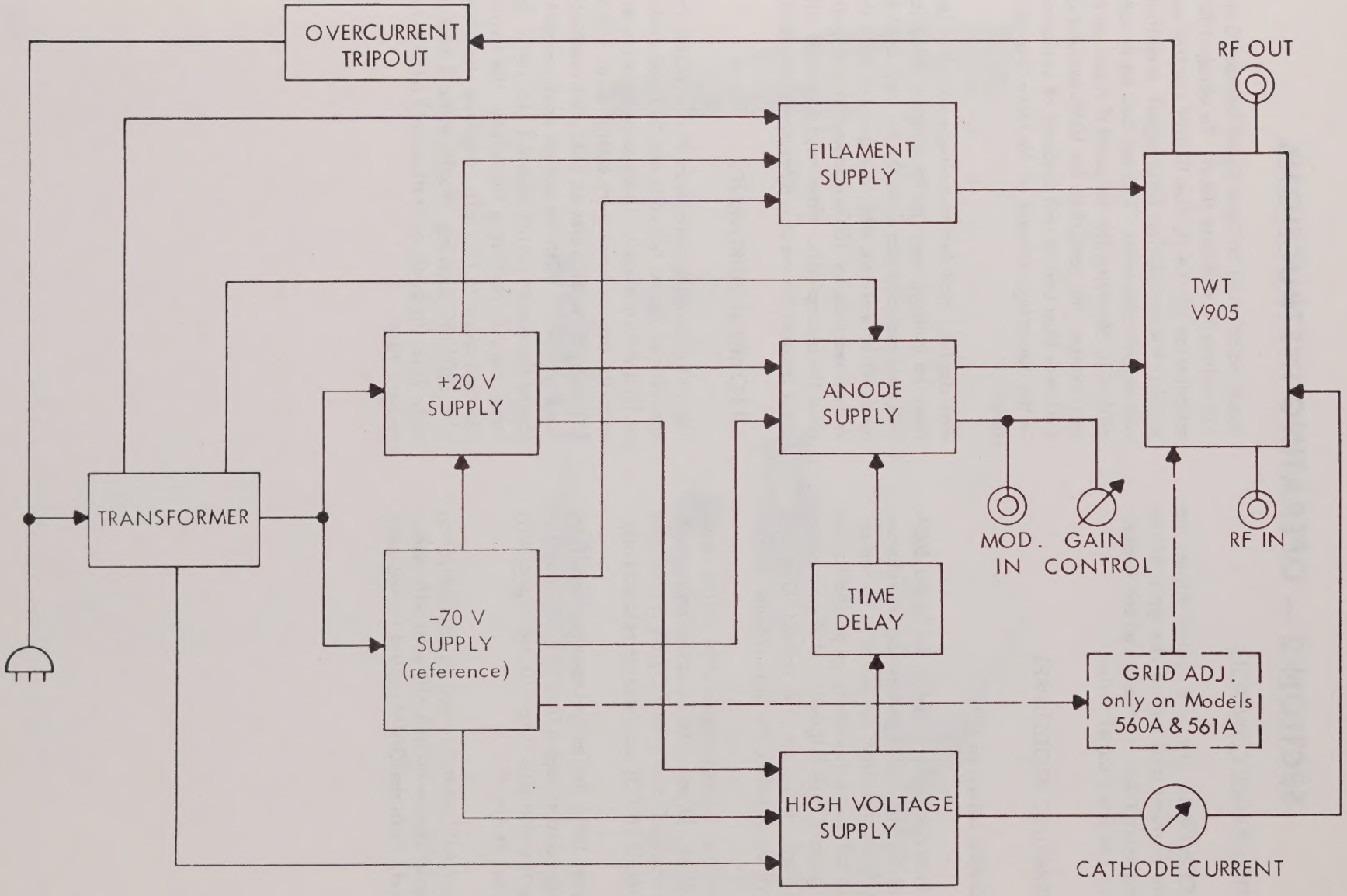


FIGURE 3-0. BLOCK DIAGRAM OF MODEL 560A SERIES TWT AMPLIFIER

SECTION 3— CIRCUIT DESCRIPTION

3.1 THE TRAVELING WAVE TUBE

The traveling wave tube consists of an electron gun, a slow wave structure (helix) and a collector at the far end of the slow wave structure. The electron gun produces a beam of electrons which travel along the axis of the helix to the collector. The forces produced by a longitudinal magnetic field, which surrounds the tube, restricts beam travel axially along the tube, just inside the helix. The rf signal to be amplified is coupled to the helix, at the electron gun end, and travels down the metallic path of the helix in the same direction as the beam. The velocity of the electron beam is determined by the potential difference between the cathode and the helix, and this voltage difference is adjusted so that the beam velocity down the tube is just a little faster than the rf wave. The alternating field produced by the rf signal causes the electrons to bunch. As the rf field advances towards the collector, it encounters more and more bunches of electrons. Amplification occurs when these groups of electrons give up energy to the rf signal as it travels down the helix. The amplified waves are then coupled off the helix through a low impedance device. Reflections are prevented by an attenuator; a lossy helix placed externally between input and output.

A more complete description of traveling wave tube theory and operation is presented in the "Engineering Notes" at the end of this manual.

3.2 POWER SUPPLIES

See Block Diagram Figure 3-0.

The unit has four independent power supplies; the +20 volt supply, the ANODE supply, the HEATER supply, and the HIGH VOLTAGE supply, all of which use a fifth supply, the -70 volt supply as a reference. The -70 volt supply, in turn, uses a temperature compensated zener diode as its reference.

3.2.1 THE +20 AND THE -70 VOLT POWER SUPPLIES (LOW VOLTAGE)

See Figure 3-1.

These two supplies consist essentially of two differential amplifiers; Q209-Q210 and Q211-Q212 for the -70 volt supply and Q203-Q204 and Q205-Q206 for the +20 volt supply. CR203 is a temperature compensated 6.2 volt zener diode and is contained on one side of the first differential amplifier of the -70 volt supply. The differential amplifiers, of each supply, feed the driver stage of power transistors Q202 (+20 volt) and Q208 (-70 volt) which are used as series regulators. The -70 volt supply can be adjusted by means of R221. A zener diode is used to start and to protect the -70 volt supply while a transistor circuit is used to start and protect the +20 volt supply.

3.2.2 THE HEATER AND HIGH VOLTAGE SUPPLIES

See Figure 3-2.

The HEATER supply for the traveling wave tube is referenced to both the +20 and -70 volt supplies, making it independent of both line and load. This 6.3 volt supply can deliver up to 2 1/2 amperes to the filament with only a nominal change in ripple or regulation.

The HIGH VOLTAGE supply (Helix and Collector) is capable of delivering 50 ma at 2.7 kv. The magnitude of this voltage is set by feedback resistors R926 through R932 and potentiometer R309. A one microfarad capacitor is used in the output of this supply to prevent fluctuations due to changes in current or load. The HELIX CURRENT TRIP-OUT circuit is essentially a

summing amplifier and operates such that if more current is taken from the base of Q401 than that specified, the succeeding amplifiers saturate causing relays K901 and K904 to trip, opening the line to the power transformers. (See Table 4-1).

3.2.3 THE ANODE SUPPLY

See Figures 3-3 and 3-4.

The ANODE supply is the most critical of all the supplies in the unit. Its function is to supply a regulated and stable voltage to the anode of the traveling wave tube and yet it must have a very fast response to meet the modulation specifications.

The anode of the traveling wave tube is a positive, low current electrode which controls cathode current and hence the gain and power output of the tube. The anode is the element that is used for the purpose of modulation. The modulation input jack is coupled to the preamplifier for the anode supply. When a modulation voltage is applied, the preamplifier drives the entire anode supply. The anode supply is adjustable by the ANODE MAX potentiometer R111 for the 560A and 561A or R119 for the 562A and 563A.

3.2.3.1 HIGH VOLTAGE ANODE SUPPLY (560A/561A). In the 560A/561A Series, High Voltage Anode Supply PC Board PC100 drives regulator amplifier tube V906 to control regulator tube V904. V904, in series with the anode supply output from PC400-10, controls the voltage applied to the TWT Anode (Grid 2) which is connected to the V904 cathode via CR914. V904 thus provides a variable voltage drop, controlled by PC100, between the PC400-10 output and the TWT. CR914 (Fig. 3-2), supplies an additional fixed drop of 56 V, with the result that the output at the TWT is controlled between 0 and + 650 V.

On PC100 (Fig. 3-3), Q103 and Q104 constitute the differential input stage of the anode supply voltage control amplifier. Three separate control inputs are supplied to Q103: (1) the feedback signal proportional to instantaneous anode voltage, tapped from the TWT anode via C915/R925 and applied to PC100-E; (2) a variable offset signal tapped from the panel GAIN Control R923 and/or a modulation input from GRID MOD INPUT jack J910, amplified by Q101; (3) a disabling signal from K902, supplied whenever high voltage is turned off by that relay, coupled to Q103 by Q102.

A negative-going signal level change at the base of Q103 causes it to conduct more heavily, driving the differential stage to reduce the conduction of Q104. Q104 controls the current through output stage Q105 which provides voltage gain. A negative-going change at the base of Q103 thus decreases the current through load resistor R120 and increases the negative voltage applied to the grid of V906 via J100-Y. This drop in grid voltage reduces the conduction of V906, thereby decreasing the drop across its load resistor R910. (R910 is connected to the regulated anode supply output voltage line PC400-7 by K905 after initial turn-on.) This drop across R910 determines the grid-to-cathode bias of V904, in this case biasing V904 to heavier conduction so that its plate-to-cathode drop is decreased, thus raising the anode voltage. Maximum output voltage at the cathode of V904 is > 706 V. This is dropped 56 V by CR914 to a maximum of > 650 V at TB901-3 to drive the TWT anode.

Conversely, a positive-going change at the base of Q103 produces a decrease in anode voltage by the reverse of the process described above. The dynamic range of the Q103/Q104 stage is such that the base of Q103 operates at or below ground level, with a ground-level signal turning "off" the anode supply output by biasing V904 to the point where its cathode is at $< +56$ V, which is translated to < 0 V at the TWT anode (TB903-3) by CR914.

Turning the GAIN control R923 CW to increase gain causes an increasingly positive voltage to

be applied to J100-B, thereby tending to decrease the forward bias of Q101 and reduce its conduction. This decreases the current through R106 and thus produces a negative-going change at the base of Q103, as required to raise the anode voltage as described above. The GAIN control and GRID MOD INPUT signals are summed at the base of Q101, allowing use of a modulation signal of either polarity by proper adjustment of the GAIN control to provide suitable offset. Thus, with the GAIN control fully CW (+20 V), Q101 is biased almost to cutoff and a 0 to -10 V MOD signal can be applied to turn it on and off for anode voltage modulation. With the GAIN control fully CCW (0 V), Q101 is biased to saturation, and a 0 to +10 V signal can be applied to turn it off and on for anode voltage modulation. The drop across R103 and the filtering action of C101 stabilizes the steady bias voltage from the GAIN control and provides isolation between the dc signal from the GAIN control and the pulsed MOD signal.

The feedback signal to J100-E tracks the instantaneous anode voltage to provide negative feedback to the base of Q103 via R111. R111 is used to set the feedback level at the maximum output point when the GAIN control is fully CW.

K902, which enables high voltage power, supplies -70 V to the base of Q102 whenever K902 is de-energized to turn off high voltage power. This -70 V input causes Q102 to saturate, thereby raising the base of Q103 to ground level, the point at which 0 V anode supply output is obtained.

3.2.3.2 LOW VOLTAGE ANODE SUPPLY (562A/563A). In the 562A/563A Series, Low Voltage Anode Supply PC Board PC100 provides output of 0 to +60 V to drive the TWT anode. Q103 and Q104 constitute a regulator circuit for the +80 V supply output from PC400-8. Q103 senses the output level at the junction between R108 and R111, and controls the conduction of Q104 so that R113 shunts the supply output by the proper amount to achieve a +80 V output level.

Q106 is the input stage of the anode supply voltage control amplifier. Three separate control inputs are supplied to Q106: (1) the feedback signal proportional to instantaneous anode voltage, tapped from the output at the collector of Q108 and impedance-converted by emitter follower Q105; (2) a variable offset signal tapped from the panel GAIN control R923 and/or a modulation input from GRID MOD INPUT jack J910, amplified by Q101; (3) a disabling signal from K902, supplied whenever high voltage is turned off by that relay, coupled to Q106 by Q102.

A negative-going signal change at the base of Q106 causes it to conduct more strongly, thereby increasing the current through R123 so that the base voltage of Q107 becomes less negative. This causes Q107 to conduct more heavily, driving the Q107/Q108 differential stage to produce a decrease in the conduction of Q108. The resultant decrease in current through R130 produces an increase in the voltage at the base of Q109. This increase drives Q109 to heavier conduction and raises the anode supply output voltage at J100-V. Conversely, a positive-going signal change at the base of Q106 produces a decrease in the anode supply output voltage.

Turning the GAIN control R923 CW to increase gain causes an increasingly positive voltage to be applied to J100-C, thereby tending to decrease the forward bias of Q101 and reduce its conduction. This decreases the current through R107 and thus produces a negative-going change at the base of Q106, as required to raise the anode voltage as described above. The GAIN control and GRID MOD INPUT signals are summed at the base of Q101, allowing use of a modulation signal of either polarity by proper adjustment of the GAIN control to provide suitable offset. Thus, with the GAIN control fully CW (+20 V), Q101 is biased almost to cutoff and a 0 to -10 V

MOD signal can be applied to turn it on and off for anode voltage modulation. With the GAIN control fully CCW (0 V), Q101 is biased to saturation and a 0 to +10 V signal can be applied to turn it off and on for anode voltage modulation. The drop across R105 and the filtering action of C101 stabilizes the steady bias voltage from the GAIN control and provides isolation between the dc signal from the GAIN control and the pulsed MOD signal.

The feedback signal from Q105 tracks the instantaneous anode voltage to provide negative feedback to the base of Q106 via R119. R119 is used to set the feedback level at the maximum output point when the GAIN control is fully CW.

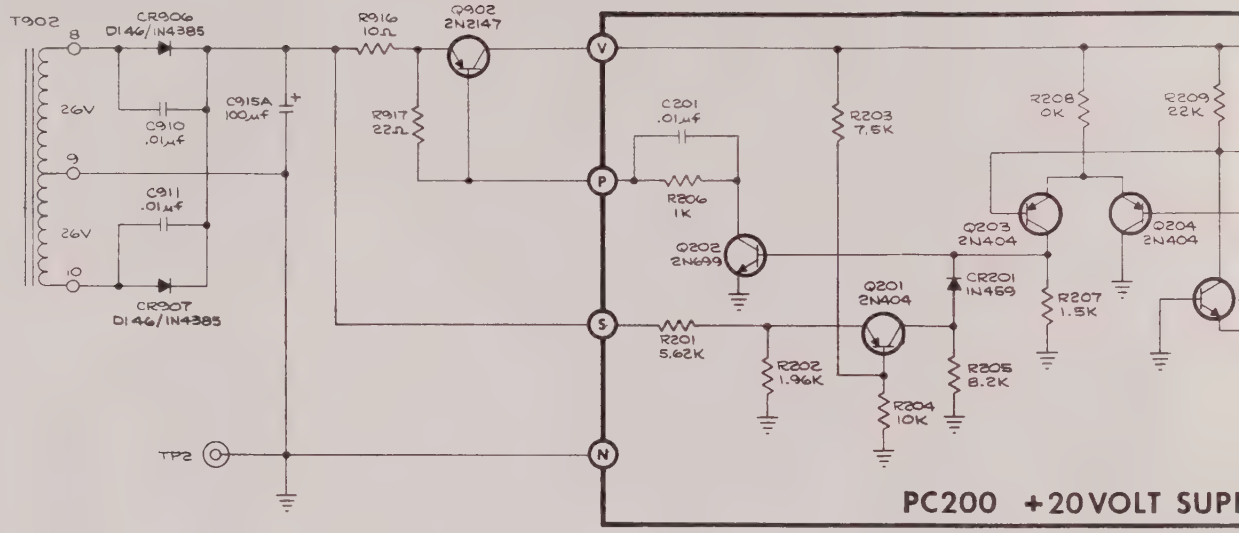
K902, which enables high voltage power, supplies -70 V to the base of Q102 whenever, K902 is de-energized to turn off high voltage power. This -70 V input causes Q102 to saturate, thereby raising the base of Q103 to ground level, the point at which 0V anode supply output is obtained.

Table 3-1. Functions of Interlock Relays and Switches in the 560A Series

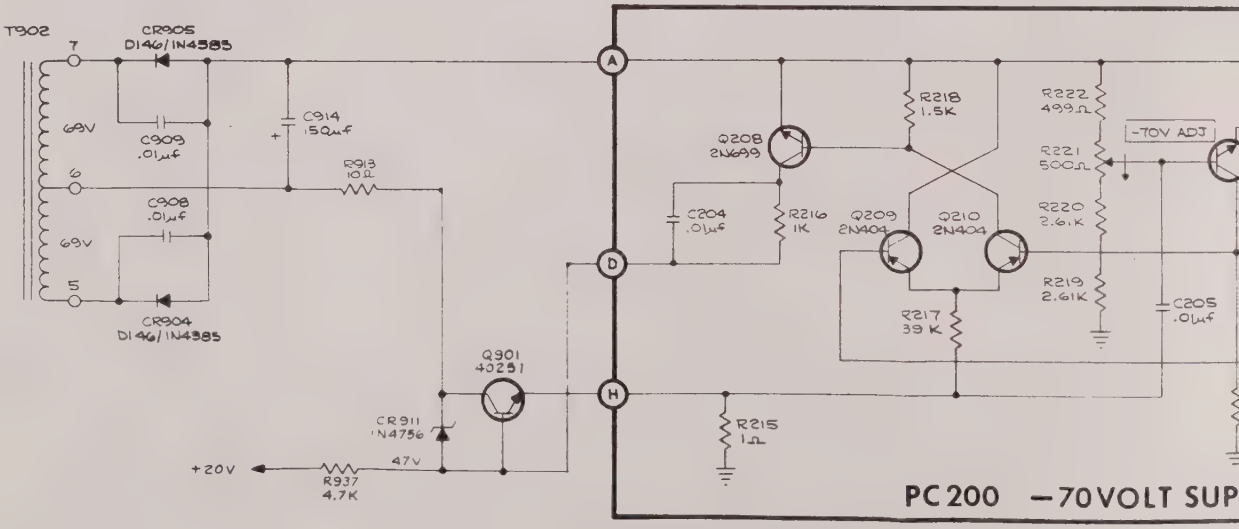
Component	Energized by	De-Energized by	Function
K901	T903, when power is connected between points Y and Y_1 (which occurs when K904 is energized due to a helix overcurrent condition). Once energized, K901 is self-latching by means of power supplied from #16-17 of T902.	Turning POWER switch off and then on, to break self-latching circuit, after helix overcurrent trouble has been corrected, so that K904 no longer completes the power circuit between points Y and Y_1.	A power control interlock relay which applies 115 V power for T901 to one contact of K902, thereby allowing K902 to energize high voltage transformer T901 except when a helix overcurrent condition exists.
K902	K906 and K903, when K906 is de-energized and K903 is energized. K906 is de-energized when a heater over-voltage condition does not exist, and K903 is energized (also by a circuit through de-energized K906) after a 90-second delay whenever power is applied to the instrument. Once energized, K902 is self-latching as long as K906 remains de-energized.	Energization of K906 due to a heater over-voltage condition, or by inoperation of time delay relay K903.	Controls primary 115 V power input to high voltage transformer T901, enabling high voltage output only when energized. When de-energized, applies -70 V to J100-Z (560A/561A) or J100-J (562A/563A) to disable the anode supply by biasing Q102 to heavy conduction, thereby dropping the anode supply output from its normal + level to ground level.
K903	K902 and K906, when both de-energized, supply power to the K903 time delay coil. The K903 contact is closed 90 seconds later.	When the K903 contact is closed after the 90-second time delay, it energizes K902, and the form C contact on K902 then de-energizes K903 at the same time it self-latches K902.	Delays turn-on of high voltage power circuits driven by T901 until the low voltage power circuits and the TWT heater driven by T902 have been allowed a 90-second warmup interval.
K904	Q402, when driven to saturation by the cutoff of Q401 when excess current is taken from the base circuit of Q401 by a helix overcurrent condition.	Cutoff of Q402 when Q401 is turned on under operating conditions where helix current is within the permissible range so that the drop across R405 is not excessive.	Turns off high voltage power for protection of the TWT against helix overcurrent, by energizing T903 which, in turn, energizes K901 when an overcurrent condition occurs, causing K901 to remove power from terminal 1 of T901.

Table 3-1. Functions of Interlock Relays and Switches in the 560A Series (cont)

Component	Energized by	De-Energized by	Function
K905	PC400 Screen Supplies and C409 (560A/561A); T902 and C914 (562A/563A), when the capacitor has charged up to relay-operating voltage after power turn-on.	Turn-off of power to instrument.	Provides a time delay in the turn-on of the Anode Supply by opening the + voltage supply line to regulator V906 (560A/561A) or grounding the +80 V supply line to J100-Z (562A/563A).
K906	Saturation of heater over-voltage amplifier Q904 when excessive heater voltage appears across R920.	Cutoff of Q904 when heater over-voltage condition is eliminated.	Through one set of contacts, breaks the heater supply circuit to J300-T to prevent over-voltage damage to the TWT heater. Through another set of contacts, de-energizes K902 to remove high voltage power (since K902, in turn, de-energizes T901).
S903 High Voltage Interlock Switch	Closed by proper installation of top cover panel.	Opened by removing top cover panel.	When closed, completes 115 V primary power circuit to T901 via K901 and K902. When opened, removes power from T901 to eliminate high voltage exposure danger.
S904 Air Flow Interlock Switch	Closed by exposure to suitable air flow pressure from fan.	Opens when insufficient air circulation exists.	When closed, completes 115 V primary power circuit to T901 via K901, K902, and S903. When opened, removes power from T901 to shut off the TWT tube in the absence of sufficient cooling air circulation.



REGULATOR BOARD



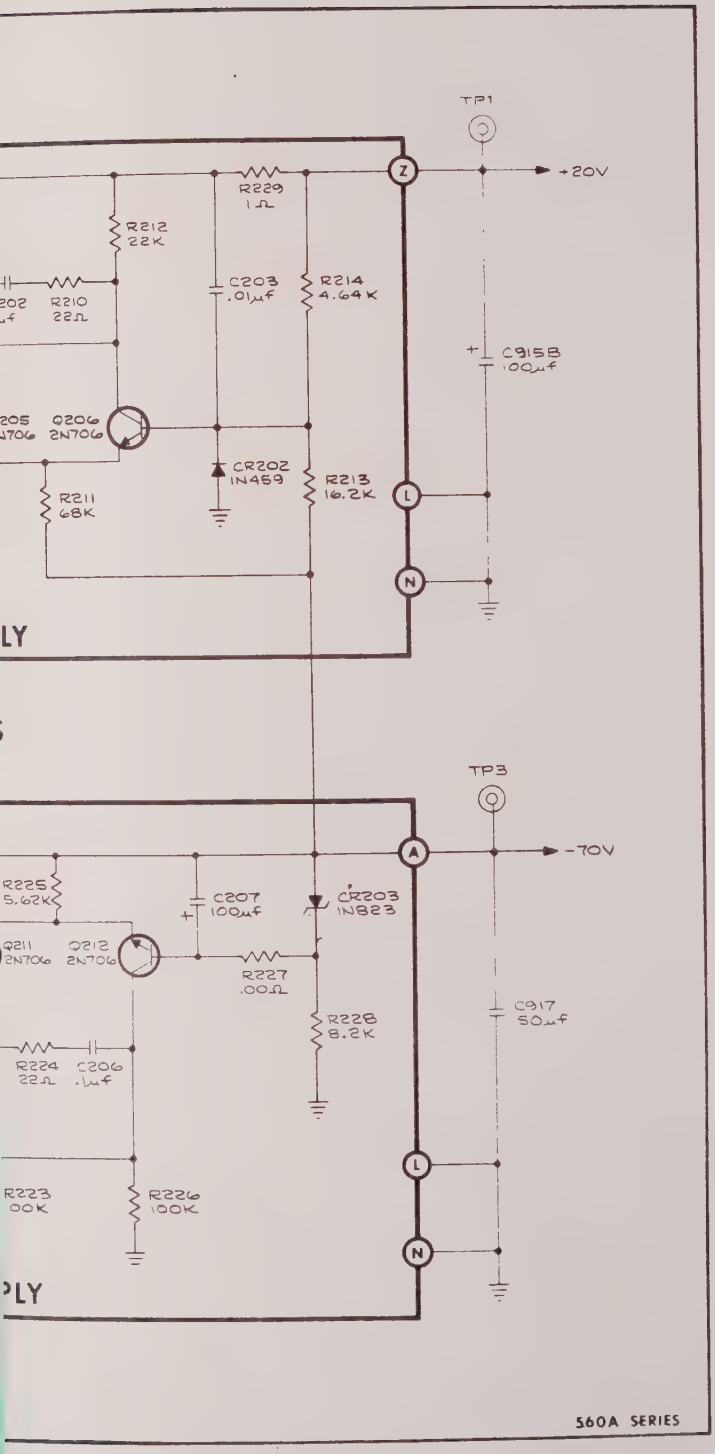
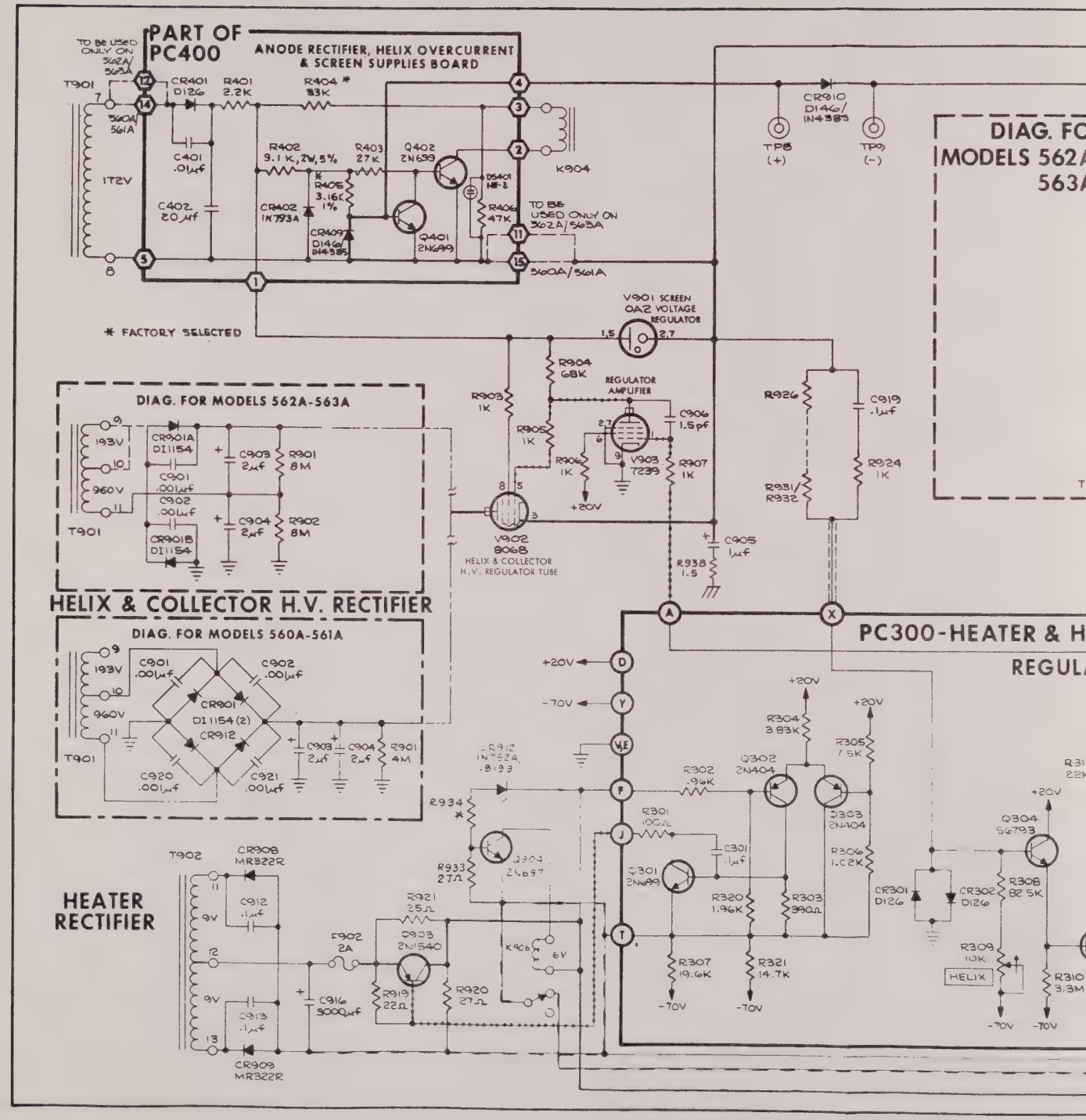


FIGURE 3-1. +20V AND -70V SUPPLIES


PART OF PC400
ANODE RECTIFIER, HELIX OVERCURRENT & SCREEN SUPPLIES BOARD
TO BE USED ONLY ON 562A/563A
T901
CR401 D126
R401 2.2K
R404 * 33K
560A/561A
C401 .01µf
R402 9.1K, 2W, 5%
R403 27K
Q402 2N699
K904
R405 3.16K 1%
CR402 IN793A
C402 20µf
CR403 D1146/IN4385
Q401 2N699
R406 47K
TO BE USED ONLY ON 562A/563A
560A/561A
117V
* FACTORY SELECTED
CR910 D1146/IN4383
TP8 (+)
TP9 (-)
DIAG. FO
MODELS 562A
563A
V901 SCREEN QA2 VOLTAGE REGULATOR
R904 68K
REGULATOR AMPLIFIER
R903 1K
R905 1K
R906 1K
C906 1.5pf
V903 7239
R907 1K
+20V
R926
C919 .1µf
R924 1K
R931/R932
V902 8068
HELIX & COLLECTOR H.V. REGULATOR TUBE
R938 1.5
C905 1µf
DIAG. FOR MODELS 562A-563A
193V
960V
CR901A DI1154
CR901B DI1154
C901 .001µf
C902 .001µf
C903 2µf
C904 2µf
R901 8M
R902 8M
HELIX & COLLECTOR H.V. RECTIFIER
DIAG. FOR MODELS 560A-561A
CR901 DI1154 (2)
CR912
C920 .001µf
C921 .001µf
R901 4M
PC300-HEATER & H
REGUL
+20V
-70V
R304 3.83K
R305 7.5K
Q302 2N404
R302 .96K
R303 2N404
R306 1.02K
R301 100Ω
C301 .1µf
Q301 2N699
R320 1.96K
R303 390Ω
R307 19.6K
R321 14.7K
R934 *
R933 27Ω
Q304 2N697
Q304 S6793
R308 82.5K
CR301 D126
CR302 D126
R309 10K
HELIX
R310 3.3M
T902
CR908 MR322R
CR909 MR322R
HEATER RECTIFIER
C912 .1µf
C913 .1µf
C916 3000µf
F902 2A
R921 25Ω
Q903 2N1540
R919 22Ω
R920 27Ω
K906
6V
9V
12
13

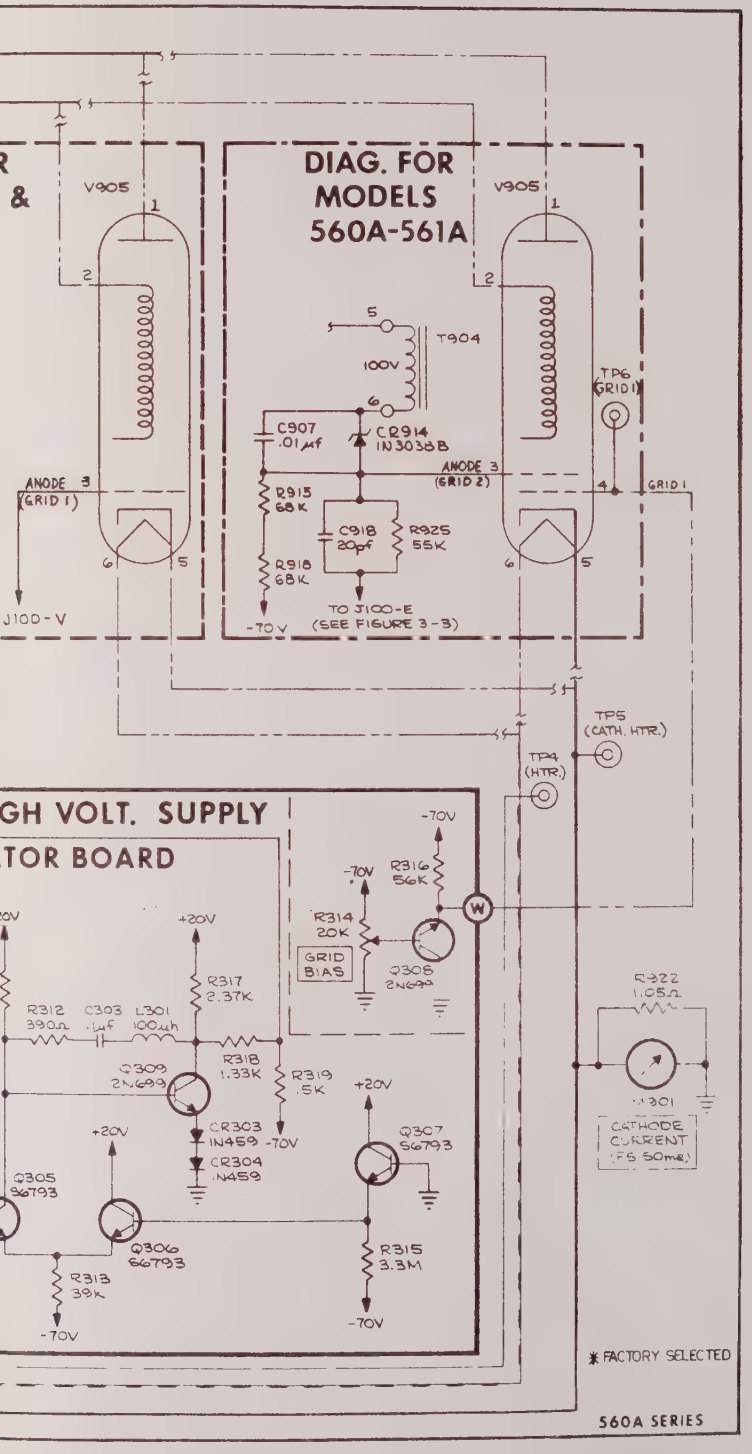
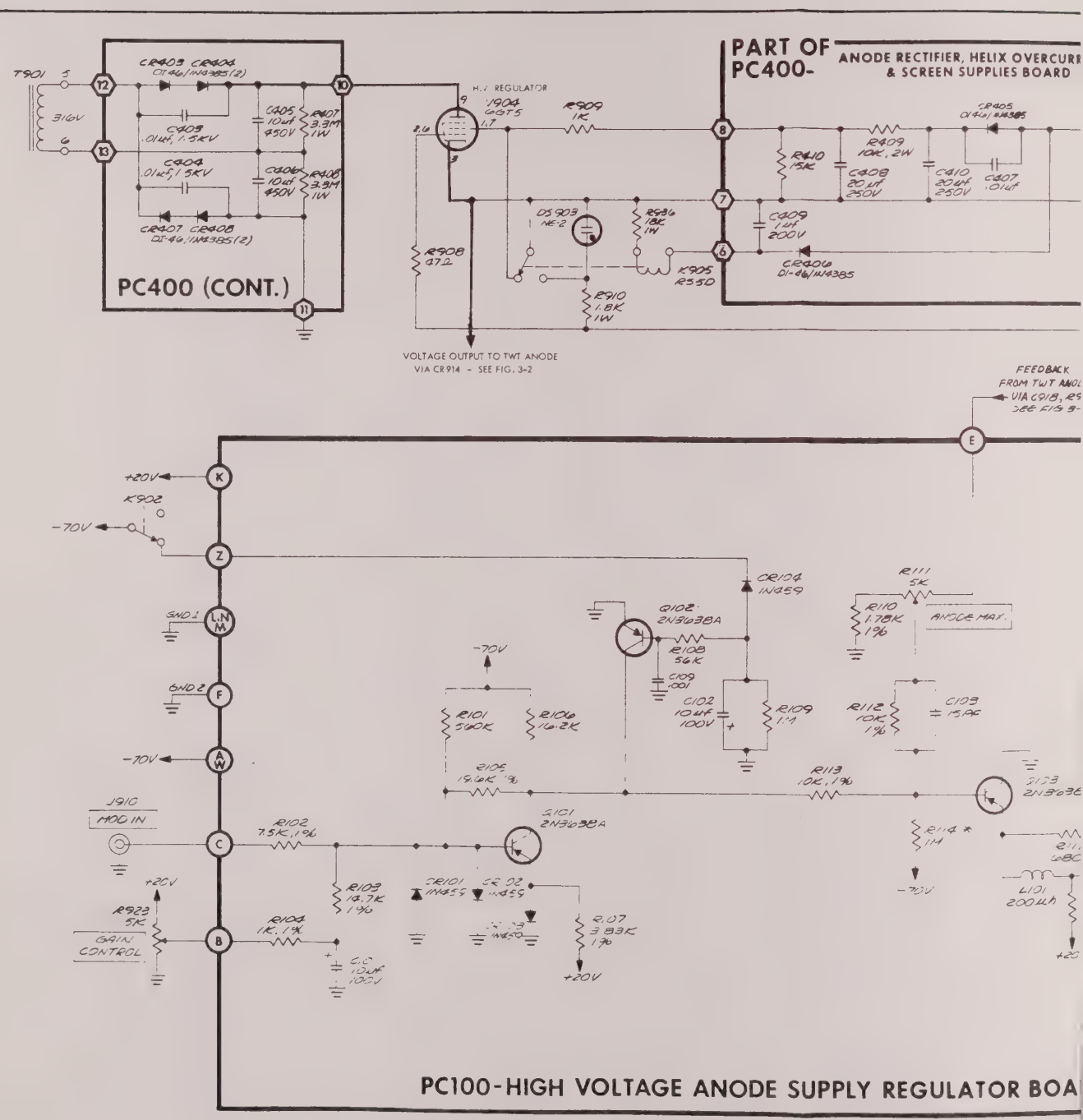
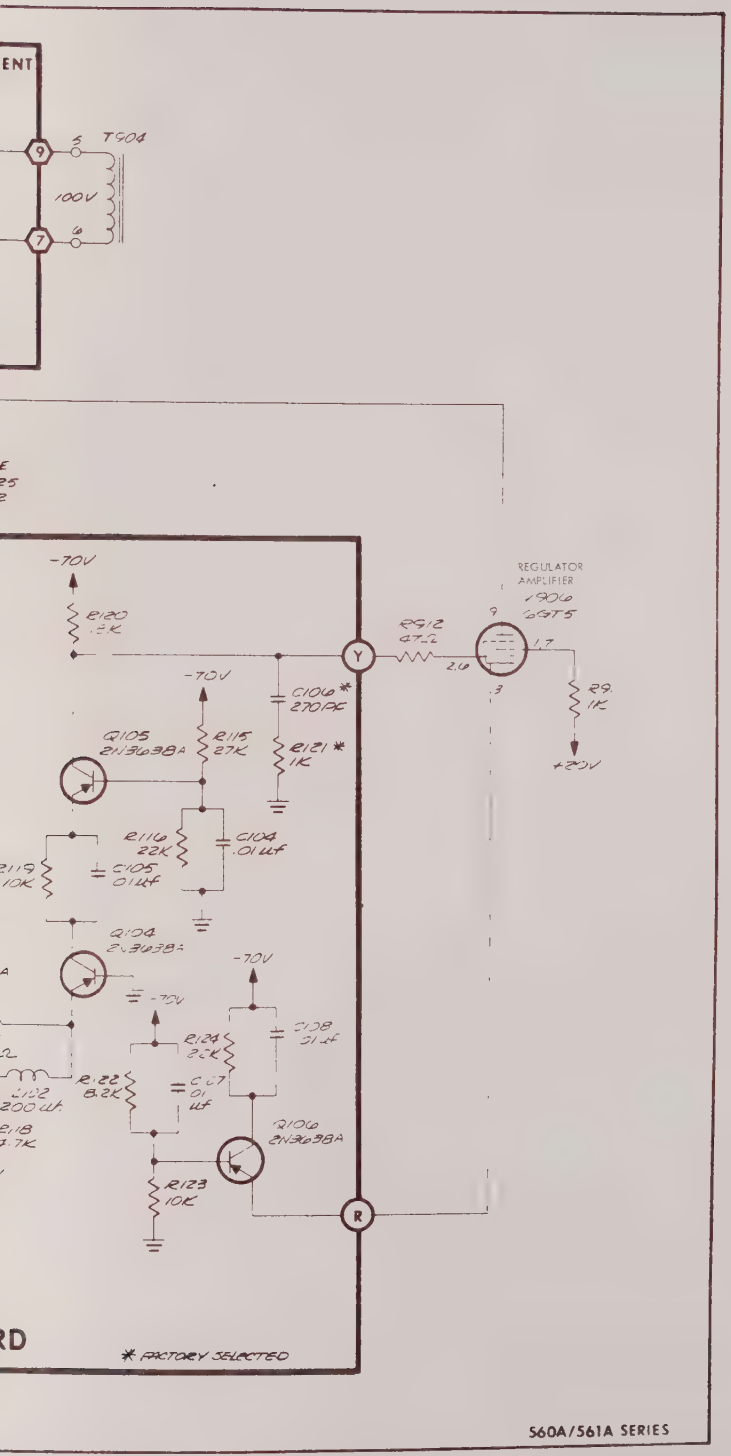


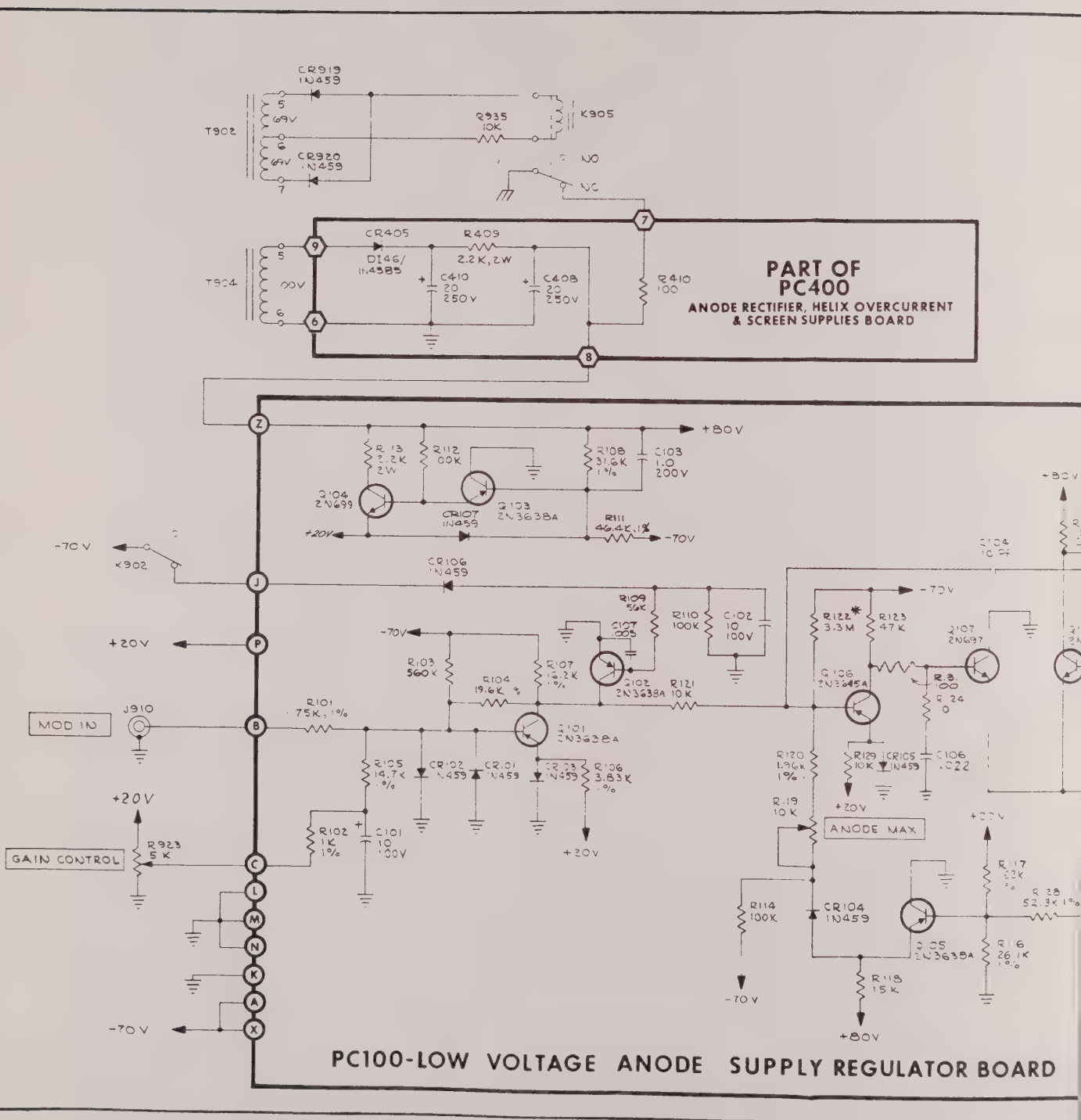
FIGURE 3-2. HEATER AND HIGH VOLTAGE SUPPLIES


PC400 (CONT.)
PART OF PC400-
ANODE RECTIFIER, HELIX OVERCURR & SCREEN SUPPLIES BOARD
T901
316V
CR403 CR404 DI-46/IN4385(2)
CR407 CR408 DI-46/IN4385(2)
C403 .01uf, 1.5KV
C404 .01uf, 1.5KV
C405 10uf 450V
C406 10uf 450V
R407 3.3MT 1W
R408 3.3MT 1W
H.V. REGULATOR
1904 6GT5
R909 1K
R908 47Ω
DS903 NE-2
R906 18K 1W
R910 1.8K 1W
K905 R550
R410 15K
R409 10K, 2W
C408 20uf 250V
C410 20uf 250V
CR405 DI-46/IN4385
C407 .01uf
C409 1uf 200V
CR406 DI-46/IN4385
VOLTAGE OUTPUT TO TWT ANODE VIA CR914 - SEE FIG. 3-2
FEEDBACK FROM TWT ANOD VIA C918, R9 SEE FIG 3-
+20V
K902
-70V
GND 1
GND 2
L.N.M
J910 MOD IN
R102 7.5K, 1%
R103 19.7K 1%
R104 1K, 1%
R923 5K GAIN CONTROL
C6 10uf 100V
CR101 IN455
CR102 IN455
CR103 IN455
R107 3.83K 1%
Q101 2N3638A
Q102 2N3638A
CR104 IN459
R108 56K
C109 .001
R101 560K
R106 16.2K
R105 19.6K 1%
C102 10uf 100V
R109 1.1
R111 5K
R110 1.78K 1%
ANODE MAX.
R112 10K 1%
C103 15pf
R113 10K, 1%
R114 * 1M
L101 200uh
PC100-HIGH VOLTAGE ANODE SUPPLY REGULATOR BOA

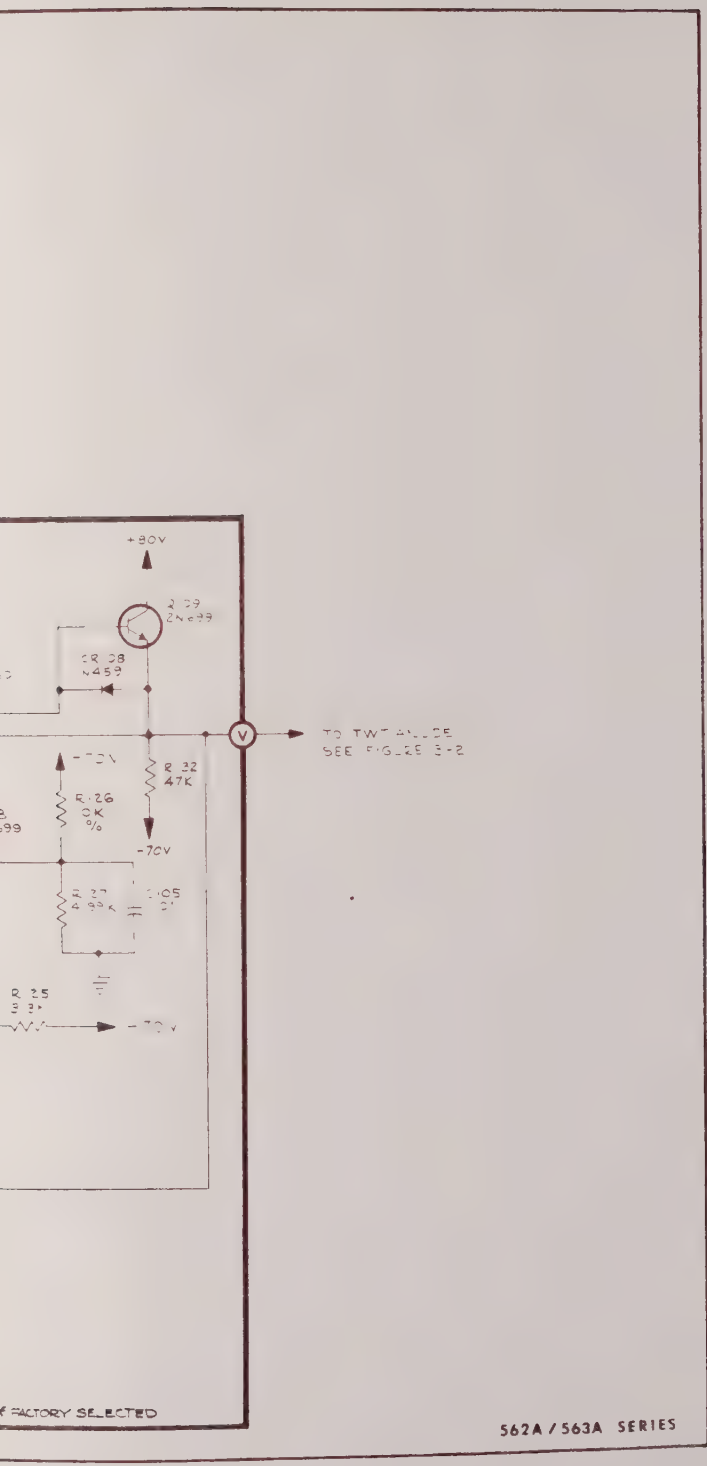
FIGURE



3-3. 560A/561A (HIGH VOLTAGE) ANODE SUPPLY


CR919 1N459
T902
5
69V
6
69V
CR920 1N459
7
R935 10K
K905
NO
NC
7
CR405
R409
2.2K, 2W
9
5
DI46/ 1N4585
C410 20 250V
C408 20 250V
R410 100
T904
100V
6
6
PART OF PC400
ANODE RECTIFIER, HELIX OVERCURRENT & SCREEN SUPPLIES BOARD
8
Z
+80V
R113 2.2K 2W
R112 100K
R108 31.6K 1%
C103 1.0 200V
Q104 2N699
Q103 2N3638A
CR107 1N459
+20V
R111 46.4K 1%
-70V
-70V
K902
CR106 1N459
J
C104 10 pf
-70V
R109 56K
R110 100K
C102 10 100V
R122* 3.3M
R123 47K
+20V
P
-70V
C107 .005
Q107 2N697
R103 560K
R107 19.2K 1%
R104 19.6K 1%
Q102 2N3638A
R121 10K
Q106 2N3645A
R3 100
R 24 0
MOD IN
J910
B
R101 75K, 1%
Q101 2N3638A
R105 14.7K 1%
CR102 1N459
CR101 1N459
CR103 1N459
R106 3.83K 1%
+20V
R120 1.96K 1%
R129 10K
CR105 1N459
C106 .022
+20V
R102 1K 1%
C101 10 100V
+20V
R19 10K
ANODE MAX
+20V
GAIN CONTROL
R923 5K
C
R117 52K 1%
R38 52.3K 1%
L
M
N
R114 100K
CR104 1N459
Q105 2N3638A
R116 26.1K 1%
K
A
R118 15K
-70V
+80V
-70V
X
PC100-LOW VOLTAGE ANODE SUPPLY REGULATOR BOARD

FIGURE



3-4. 562A/563A (LOW VOLTAGE) ANODE SUPPLY

SECTION 4 — MAINTENANCE

4.1 PERIODIC MAINTENANCE

Perform the following maintenance on the Model 560A at least every six months or as often as necessary:

a. Remove all accumulated dust with forced air.

b. Visually inspect the unit for loose or broken connections, loose panel controls or connections, improperly seated tubes, bent or broken tube pins, etc. Replace worn-out components as required.

c. Check voltages at test points as directed in Paragraph 4.2.

d. Make a performance check in accordance with the procedure of Paragraph 4.6.

CAUTION: High voltages within the chassis of this instrument constitute a hazard to anyone performing maintenance on the unit. Before working on this instrument, carefully read all of Section 4 of this manual.

4.2. VOLTAGE MEASUREMENTS AT CHASSIS TEST POINTS.

Test points are provided underneath the top cover of the Model 560. Removal of the top cover disables the high voltage, and will therefore require "cheating" of the top cover interlock switch to make high voltage tests.

4.2.1 SUPPLY VOLTAGE MEASUREMENTS

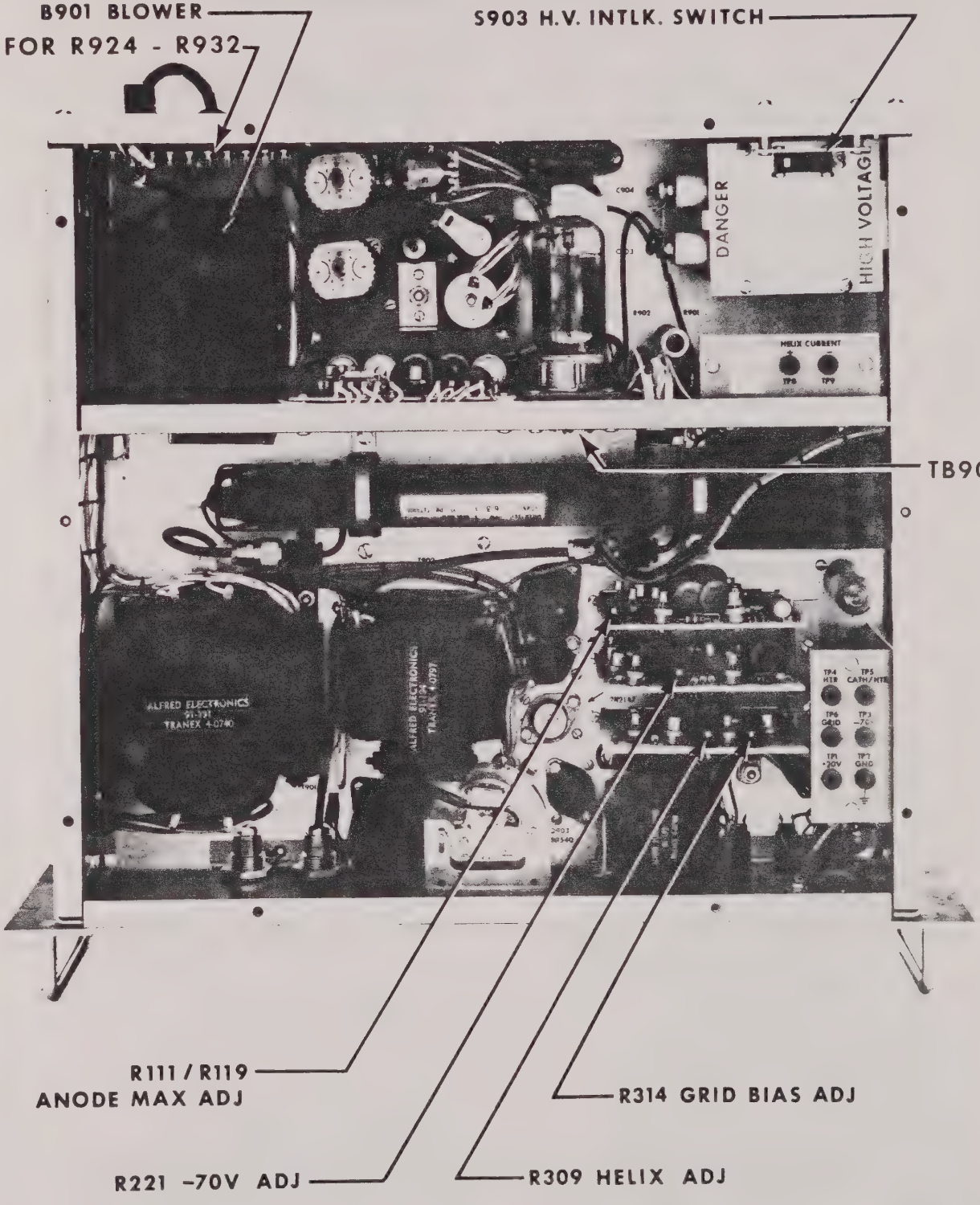
Supply voltages and tolerances are given in Table 4-2. Pay attention to the test instrument polarities shown, in order that test equipment, the instrument under test, and personnel testing the instrument not be harmed. Make connections before applying high voltage.

4.2.2 TEST EQUIPMENT

The test instruments listed in Table 4-1, or their equivalents, should be used in making maintenance checks.

Table 4-1. Recommended Test Equipment.

Instrument	Manufacturer/Model No. (or equivalent)
Digital Voltmeter (for precise low-voltage measurements)	HP: 3459A or HP/3430A (four or five-place; up to 600 V)
Vacuum Tube Voltmeter (for high-voltage measurements)	HP: 410B with 11044A DC Divider (up to 2600 V)
Network Analyzer (for power level and rf performance measurements)	Alfred: 8000/7051 with 1403 Crystal Detector Set
Alternate for Network Analyzer: Power Meter	HP: 431C
Floating Multimeter (for current measurements)	Triplett: 630A
Metered Variac (for line voltage variation simulation)	Gen. Radio: WSMT3W
Sweep Oscillator (rf source to drive amplifier for rf tests)	Alfred: 650 with plug-in oscillator head for the frequency range of interest.
Variable RF Attenuator (to vary rf source power for gain tests)	Alfred: E100 Series unit for the frequency range of interest.
RF Pad Attenuators (to reduce amplifier rf output to power meter)	Narda: 777, 20 db and 6 db for the frequency range of interest.



TOP VIEW

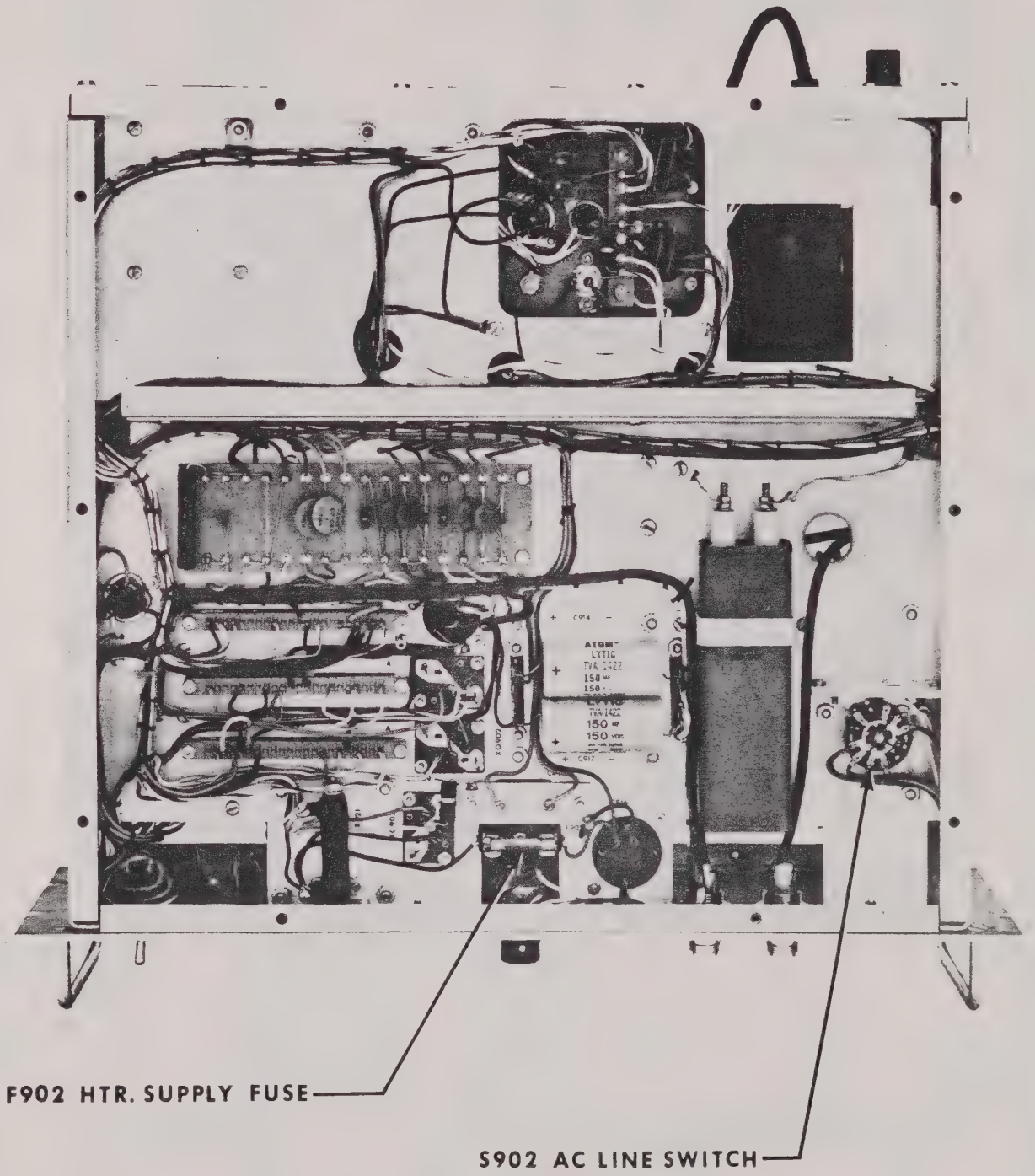
FIGURE 4-1

Table 4-2. Voltage Measurements

Group 1 - Low-Voltage and Medium-Voltage Supply Checks (these checks are made with a floating digital voltmeter)

Voltage	Set To	Adjust	Ripple	Test Points and Signal Polarity (-)		(+)
[Low Voltage Supplies]						
-70 V	-70.00 ± .05 V	R221	6 mv.	TP3	t	TP2
+20 V	+20.0 ± .6 V	Adjustment of +20 V supply relies on initial adjustment of -70 V supply. If -70 V supply is set correctly, +20 V supply should be in spec.	3 mv.	TP2	t	TP1
+6.3 V (Measure with high voltage off, i.e. do not defeat top cover interlock)	+6.3 ± .3 V	Adjustment of 6.3 V supply relies on initial adjustment of -70 V supply. If -70 V supply is set correctly, 6.3 V supply should be in spec.	500 mv.	TP5		TP4
[Focusing Grid (560A/561A only)]						
Grid #1 (560A/561A)	Check envelope at rear of manual	R314		TP6	t	TP2
[Anode]						
Grid 2 (560A/561A)	Check envelope at rear of manual	R111 (560A/561A)	50 mv.	TP2	t	TB901-3
Grid 1 (562A/563A)	Check envelope at rear of manual	R119 (562A/563A)	50 mv.	TP2	t	TB901-3
Group 2 - High-Voltage Supply Check (this check is made using a Vacuum-Tube voltmeter with high-voltage probe; top cover interlock must be defeated to energize high voltage).						
[Helix]						
Helix (Cathode)	Check envelope at rear of manual	R309	6 mv.	TP2		TP8
Group 3 - Helix current check (this check is made with an insulated, floating multimeter in the 10 ma range with high voltage on)						
Helix I	Check envelope at rear of manual	See par. 4-4.		TP9		TP8

t If the recommended voltmeter is used, the LOW level probe should be attached to TP2 (chassis ground) for all Group 1 measurements except +6.3 V.



BOTTOM VIEW

FIGURE 4-2

4.3 TROUBLE SHOOTING

4.3.1 STEPS TO FOLLOW WHEN FAILURE OCCURS.

First check all voltages, if possible, in accordance with Paragraph 4.2.1 (Table 4-2).

> NOTE: Before attempting to trouble-shoot the unit, ascertain that the apparent trouble is actually due to a malfunction within the instrument and not to improper usage.

If power supply problems rule out voltage checks, refer to Table 4-3 for help in trying to localize the instrument failure.

4.3.2 USE OF THE TROUBLE-SHOOTING TABLE.

Table 4-3 provides basic trouble shooting information for the Model 560 instrument. Use of this table will help to localize a malfunction to a specific circuit or circuits.

4.4 INTERNAL ADJUSTMENTS.

The Model 560 instruments contain four internal potentiometers used for calibration of the unit. The following paragraphs contain pertinent information concerning these potentiometers, their adjustment, and their use and affect on Model 560 performance.

4.4.1 LOW VOLTAGE (-70 V) ADJUSTMENT.

The -70 V Adjust (R221) is used to calibrate the -70 V supply. This calibration also serves as the regulating reference for the +20 V and 6.3 V supplies. Adjust R221 only when necessary to bring the -70 V supply into spec. This will automatically calibrate the +20 V and 6.3 V supplies unless they are defective.

The -70 V Adjust (R221) is factory set and should NOT require readjustment unless components in the -70 V, +20 V, or 6.3 V supplies have been repaired or replaced.

4.4.2 HELIX ADJUSTMENT.

The Helix Adjust (R309) sets and calibrates the high voltage. The Helix Adjust (R309) is preset at the factory to provide optimum performance of the Model 560. Do not readjust this control to raise the voltage beyond that specified in the Test Data Sheet which is in the envelope at the rear of this manual while the instrument is in warranty.

If, after extended use, there is insufficient uniform rf gain across the band, it maybe possible to restore gain to the original spec level by readjustment of R309 within the limits shown in Table 4-4 during sweep mode, with the GAIN Control full On.

> CAUTION: Do not attempt to exceed the maximum Cathode Current (monitored by the front-panel meter) or the Helix Current trip-out level specified in Table 4-4.

4.4.3 ANODE VOLTAGE ADJUSTMENT. (Grid #2, 560A/561A) (Grid #1, 562A/563A)

The Anode Max. Control (R111 for the Model 560/561, R119 for the Model 562/563) is set at the factory to provide rated power output across the full band. Do not adjust this control to raise the voltage beyond that specified in the test data sheet which is in the envelope at the rear of this manual while the instrument is in warranty unless rf output falls below rated power.

If, after extended use, there is insufficent power output across the band, first check the helix voltage adjustment (Par. 4.4.2) for adequate gain and optimum response across the band. Then adjust R111 (560A/561A) or R119 (562A/563A) within the limits shown in Table 4-4 to restore power output to the original spec level, provided maximum Cathode current is not exceeded.

4.4.4 FOCUSING GRID BIAS ADJUST. (560A/561A only; Grid 1)

Adjustment of the Grid Bias Adjust potentiometer (R314) provides the regulation of the voltage supply which sets the focus voltage at Grid #1 of the TWT (560A/561A only.)

This control is preset at the factory and should not require readjustment unless components on PC Board 300 or the TWT have been replaced. This voltage should be adjusted to the value specified in the test data sheet in the envelope at the rear of this manual. If a helix voltage adjustment (Par. 4.4.2) is required to maintain an optimum gain curve across the band, try re-adjusting R314 within the limits shown in Table 4-4 to provide optimum response at any setting of the helix voltage.

4.5 REPLACEMENT OF THE TWT.

To replace the Traveling Wave Tube, use the following procedure:

a. Remove the top and bottom cover plates.

b. Disconnect all TWT connections from TB 901. (On units with Serial Nos. 60 and below, two connectors, P913 and J913, were used in place of Terminal Board TP901. On these units, disconnect P913 from J913).

c. Disconnect the RF connections from the TWT to the unit.

NOTE: If it is necessary to replace the RF input and output connectors and cables, use the cables supplied with the replacement tube. Drop the front panel of the unit and attach the new cables supplied with the replacement TWT.

d. Remove the four bolts securing the TWT to the unit chassis.

e. Remove the old tube.

f. Secure the new tube to the chassis.

NOTE: If the new tube comes supplied with a Winchester connector, remove the Connector; replace with terminal lugs and attach to TB901 as described in Fig. 4-3.

CAUTION!! Be sure proper tube to terminal connections are made on TB901.

g. After the replacement TWT is installed check Grid #1, Grid #2, and Helix voltages and adjust these to the voltages specified in the Tube Data Sheet supplied with the replacement TWT. (See pars. 4.4.2 through 4.4.4.)

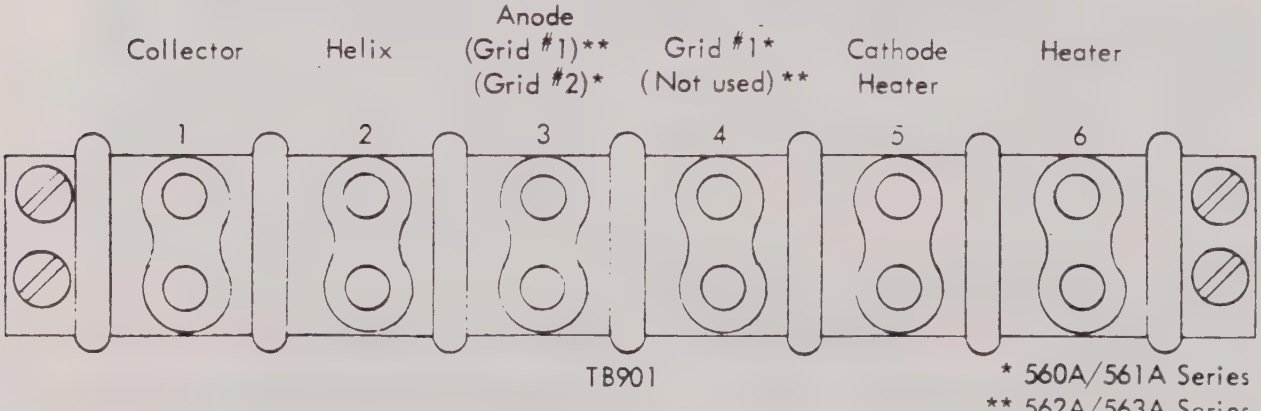


Figure 4-3

Model 560 Trouble Shooting Chart (Table 4-3)

Trouble Indication	Suggested Cause and Remedy
1. Power Fuse (F901) blows.	a. Check primary power circuit for shorts. b. Measure output impedance of the +20 and -70 V supplies (when de-energized). The value should be greater than 100 Ω for each supply. If not, trouble-shoot the low voltage PC Board. c. Check low voltage rectifiers. d. Check for shorts across transformer T902.
2. High Voltage Fuse (F902) blows. CAUTION: Remove thermal relay K903 to disable high voltage.	a. Measure low voltage supplies (dc check per table 4-2). b. Check high voltage rectifiers. c. Check the impedance of the high voltage and anode screen supplies for shorts. d. Check for burned-out resistors on the high voltage PC Board (PC 300).
3. Power Lite On with H.V. Lite On for only an instant. The sequence of events leading to this problem is: Power Lite is On High Voltage Lite comes on 90 seconds later Overcurrent Relay instantaneously trips out High Voltage Lite goes out.	a. Check for magnetic sources near the unit. b. Disconnect the Traveling Wave Tube after turning power off and waiting 2 minutes for voltage decay. Then turn power on and check for presence of high voltage. If there is high voltage, either the Anode or Helix voltages may not be regulating, causing that supply to assume raw maximum voltage. This indicates an open loop condition in the high voltage supply. Check the grid, anode, and helix supplies per table 4-2. If voltages are incorrect, check for disconnected wires to the control grid of one or more regulator tubes, and check to see whether the feedback resistors are intact. c. If there is no high voltage, see if control tube V903 is conducting heavily by checking its control grid voltage (pin 1). The value should be approximately -1.5 volts. If the tube is conducting heavily, check the high voltage PC Board. d. If the high voltage and anode supplies regulate simultaneously, check the TIME DELAY circuit and the relay contacts that feed the TIME DELAY circuit. (Be sure the time delay circuit is initially activated.)

Table 4-3 is continued on page 4-8.

Model 560 Trouble Shooting Chart (Con't.)

Trouble Indication		Suggested Cause and Remedy
4. No RF with high voltage and power ON. CAUTION: Make sure at least 1 mv of power is supplied to the RF INPUT.	a.	Check for proper Cathode current.
	b.	Check helix supply per Table 4-2. If improper supply voltage is obtained, check V901, V902, V903 and other components in the helix supply.
	c.	Check the traveling wave tube power connections.
	d.	If there is no Cathode current, check that all modulation inputs are removed.
	e.	With the modulation voltage disconnected, rotate the GAIN control from full On to full Off. If the GAIN control has little or not effect on cathode current, as seen on the panel meter, check the Anode voltage per Table 4-2. The voltage should agree with that given in the test data sheet in the envelope at the rear of this manual when the GAIN Control is fully CW, and decrease as the GAIN control is turned CCW. If it does not check out, check for defective components in the anode supply (PC 100). (In the 560A/561A, try replacing V904 and V906, and also check the Anode feedback network R925/C918.)
	f.	Check GAIN Control potentiometer R923.
	g.	Check anode rectifiers and screen supplies on PC 400. (Check raw supply voltages.)
	h.	Check TWT filament (TWT filament heater voltage and heater supply fuse F902).
5. No modulation.		Check the preamplifier circuitry, the wiring to the preamplifier circuit and the modulation input to the anode supply PC Board (PC 100).
6. Power lite On but no high voltage after 90 seconds.	a.	Check thermal relay K903.
	b.	Check the high voltage interlock, S903.

Table 4-4. TWT Voltage Adjustment Limits†

MODEL	TUBE TYPE	FREQ. GHz	HELIX E MIN	HELIX E MAX	HELIX I MAX	GRID #1 E MIN	GRID #1 E MAX	GRID #2 E MIN	GRID #2 E MAX	CATHODE I MAX
560A	M4268K	1 - 2	635	685	8 ma	-60	-25	350	550	45 ma
561A	M4260K	2 - 4	775	825	8 ma	-60	-25	350	550	45 ma
SPEC	M4260KE	1.7 - 4.2	775	825	8 ma	-60	-25	350	550	45 ma
562A	M4278K	4 - 8	1875	2025	3.5 ma	20	60	NA	NA	30 ma
SPEC	M4278KE	3.7 - 8.3	1875	2025	3.5 ma	20	60	NA	NA	30 ma
563A	M4273K	7.0-12.4	2375	2525	3.5 ma	20	60	NA	NA	30 ma

† Refer to the instrument test data sheet in the envelope at the rear of this manual for factory voltage settings which should be satisfactory during the warranty period.

To extend tube life after the warranty period, adjustment of Helix Voltage may be made to maintain an optimum output curve across the band. The Grid 2 Voltage (560A/561A) or the Grid 1 Voltage (562A/563A) may be adjusted to restore power output to specification level.

The Grid 1 voltage on the 560A/561A provides beam focusing and should not need to be adjusted from the data sheet value except in conjunction with a helix voltage readjustment to maintain an optimum output curve across the band. (See paragraphs 4.4.2 through 4.4.4.)

4.6 PERFORMANCE CHECK

This check should be made at least every six months or when repairs or replacements have been made.

> CAUTION: The signal source (Model 650 Plug-in) and ALL RF components (attenuators, etc.) in the test circuit must be for the same frequency band as the Model 560A Series unit being checked.

a. Connect the RF Output of the Alfred Model 650 Oscillator Plug-in Unit to the Model E100 Series Attenuator. Set the attenuator to provide 20 db attenuation. Set the Model 650 for full-band swept operation, Retrace ON, at the maximum power output that can be achieved with full-band leveling (UNLEVELED light off). Connect the output of the Model E100 Series attenuator to the power monitor (Model 8000/7051 Network Analyzer and Model 1403 Crystal Detector, or Model 431C Power Meter).

b. Observe the reading on the power monitor. Slowly adjust the E100 Series attenuator until the power monitor reads 0 dbm. This calibrates the RF output from the E100 Series attenuator. Disconnect this 0-dbm lead from the power meter and connect it instead to the RF INPUT of the Model 560A.

c. Connect the RF OUTPUT of the Model 560A through two pad attenuators providing 26 db attenuation to the power monitor.

NOTE: If a power meter is used, set the Model 650 Sweep control to SINGLE. Press the Sweep Trigger button to provide an indication on the power meter. If the 8000/7051 Network Analyzer is used, the Model 650 may be operated in a swept mode for continuous display.

d. Verify that the Model 560A power output remains greater than +4 dbm as read on the power monitor. (This, combined with the 26 db rf output attenuation equals the 30 db gain specification.)

e. Compare the output performance across the band with the factory performance graph given in the envelope at the rear of this manual. If considerably greater gain variation is experienced across the band, refer to par. 4.4.2 for a helix voltage check and adjustment.

f. If power output is low at any point within the band, refer to par. 4.4.3 and adjust the anode voltage as required to obtain the required power.

g. Repeat step d (and steps e and f as necessary) to insure that performance at all points within the band is within specifications.

SECTION 5 - PARTS LIST

CHASSIS AND PC BOARD ASSEMBLIES
MODELS 560A/561A

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	SCHEMATIC
900 and 400		Main Chassis	D 900777-2
PC 100	950831	High Voltage Anode Supply PC Board	D 900778
PC 200	901274	Low Voltage Supplies PC Board	C 900862
PC 300	950390	Heater and High Voltage Supply PC Board	C 900863

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		CAPACITORS		
C101 and C102	13-33	10 mf, Fixed, Elect., 100 v	56289	TE 1407
C103	11-6	15 pf, Fixed, Mica, 5%	72136	DM15C150J
C104 and C105	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
C106*	12-27	270 pf, Fixed, Cer., 1000 v	71590	DD271
C107 and C108	12-3	Same as C104		
C109	12-13	.005 mf, Fixed, Cer., 500 v	71982	811-Z5V-502T
C201	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
C202	12-34	1 mf, Fixed, Cer., 100 v	91418	BT 010
C203 thru C205		Same as C201		
C206		Same as C202		
C207	13-40	100 mf, Fixed, Elect., 10 v	56289	TE 1119.3
C301	12-34	.1 mf, Fixed, Cer., 100 v	91418	BT 010
C302		Not used		
*C303		Same as C301		
C401	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
C402	13-21	20 mf, Fixed, Elect., 250 v	56289	TVA 1508
C403 and C404		Same as C401		
C405 and C406	13-42	10 mf, Fixed, Elect., 450 v	56289	TVA 1705
C407		Same as C401		
C408		Same as C402		
C409	14-13	1 mf, Fixed, Paper, 200 v	00656	P8292 ZN13
C410		Same as C402		
C901 and C902	12-28	.001 mf, Fixed, Cer., 6000 v	71590	DD60-102
C903 and C904	15-18	2 mf, Fixed, Paper, 2000 v	99120	LK 20-205
C905	15-20	1 mf, Fixed, Paper, 3000 v	99120	LK 30-105
C906	12-30	1.5 pf, Fixed, Cer., 6000 v	56289	60-GA-Y15
C907 thru C911	12-3	.01 mf, Fixed, Cer., 600 v	71590	DA-049-211CB
C912 and C913	12-34	.1 mf, Fixed, Cer., 100 v	91418	BT 010
C914	13-4	150 mf, Fixed, Elect., 150 v	56289	D 26978
C915	13-36	100 100 mf, Fixed, Elect., 50 v	56289	TVL 2326
C916	13-9	3000 mf, Fixed, Elect., 15 v	37942	WPC 42A
C917		Same as C914		
C918	12-43	20 pf, Fixed, Cer., 1000 v	71590	DD200
C919	16-5	.1 mf, Fixed, Plastic, 3000 v	99120	OF-30-104
C920 and C921	12-28	Same as C901		

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		DIODES		
CR101 thru CR104	81-41	1N459	93332	1N459
CR201 and CR202	81-41	1N459	93332	1N459
CR203	81-75	Zener, 1N823, 6.2 v	04713	1N823
CR301 and CR302	81-20	DI-46/1N4385	12060	DI-46
CR303 and CR304	81-41	1N459	93332	1N459
CR401	81-20	DI-46/1N4385	12060	DI-46
CR402	81-96	1N973A	04713	MR 5228
CR403 thru CR409		Same as CR401		
CR901	81-69	DI-1154	12060	DI-1154
CR902 and CR903		Not used		
CR904 thru CR907	81-20	DI-46 1N4385	12060	DI-46
CR908				
CR909	81-93	MR322R	04713	MR 3229
CR910		Same as CR905		
CR911	81-125	1N4756	04713	1N4756
CR912	81-69	Same as CR901		
CR913	81-77	Zener, 1N752A	59942	1N752A
CR914	81-31	Zener, 1N3038B (56 v, 1 w)	04713	MZ2038B
		TRANSISTORS		
Q101 thru Q106	81-114	2N3638A	07263	2N3638A
Q201	81-51	2N404	07029	2N404
Q202	81-72	2N699	96214	2N699
Q203 and Q204		Same as Q201		
Q205 and Q206	81-73	2N706	07029	2N706
Q207		Not used		
Q208		Same as Q202		
Q209 and Q210		Same as Q201		
Q211 and Q212		Same as Q206		
Q301	81-72	2N699	96214	2N699
Q302 and Q303	81-51	2N404	07029	2N404
Q304 thru Q307	81-115	2N3565	07263	2N3565
Q308 and Q309		Same as Q301		
Q401 and Q402	81-72	2N699	96214	2N699
Q403	81-52	40251	04713	40251
Q404	81-74	2N2147	07029	2N2147
Q405	81-74	2N1540	04713	2N1540
Q406	81-71	2N697	96214	2N697

*Factory Select

PARTS LIST - MODELS 560A/561A

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		RESISTORS		
R101	41-560 K	560 K, 1/2 w, Fixed, Comp, 10%	01121	EB 5641
R102	56-7.5 K	7.5 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-7.5 K
R103	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-14.7 K
R104	56-1 K	1 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-1 K
R105	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-19.6 K
R106	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-16.2 K
R107	56-3.83 K	3.83 K, 1 2 w, Fixed, MF, 1%	19701	MF-&C-TO-3.83 K
R108	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%	01121	EB 5631
R109	41-1 M	1 M, 1/2 w, Fixed, Comp., 10%	01121	EB 1051
R110	56-1.78 K	1.78 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.78 K
R111	71-94	5 K, Variable, WW, 20 turn	96791	2600-5 K
R112 and R113	56-10 K	10 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-10 K
R114 *	41-1 M	1M, 1 2 w, Fixed, Comp., 10%	01121	EB 1051
R115	41-27 K	27 K, 1 2 w, Fixed, Comp., 10%	01121	EB 2731
R116	41-22 K	22 K, 1 2 w, Fixed, Comp., 10%	01121	EB 2231
R117	41-680 Ω	680 Ω, 1 2 w, Fixed, Comp., 10%	01121	EB 6811
R118	41-4.7 K	4.7 K, 1 2 w, Fixed, Comp., 10%	01121	EB 4721
R119	41-10 K	10 K, 1 2 w, Fixed, Comp., 10%	01121	EB 1031
R120	41-18 K	18 K, 1 2 w, Fixed, Comp., 10%	01121	EB 1831
R121 *	41-1 K	1 K, 1 2 w, Fixed, Comp., 10%	01121	EB 1021
R122	41-8.2 K	8.2 K, 1 2 w, Fixed, Comp., 10%	01121	EB 8221
R123		Same as R119		
R124	41-2.2 K	2.2 K, 1 2 w, Fixed, Comp., 10%	01121	EB 2221
R201	56-5.62 K	5.62 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-5.62 K
R202	56-1.96 K	1.96 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.96 K
R203	56-7.50 K	7.50 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-7.50 K
R204	56-10 K	10 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-10 K
R205	41-8.2 K	8.2 K, 1 2 w, Fixed, Comp., 10%	01121	EB 8221
R206	42-1 K	1 K, 1 w, Fixed, Comp., 10%	01121	GB 1021
R207	41-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1521
R208	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1031
R209	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%	01121	EB 2231
R210	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 2201
R211	41-68 K	68 K, 1/2 w, Fixed, Comp., 10%	01121	EB 6831
R212	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%	01121	EB 2231
R213	56-16.2 K	16.2 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-16.2 K
R214	56-4.64 K	4.64 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-4.64 K
R215	44-1.0 Ω	1.0 Ω, 1 2 w, Fixed, Comp., 5%	75042	BWH-1.0 Ω
R216	43-1 K	1 K, 2 w, Fixed, Comp., 10%	01121	HB 1021
R217	41-39 K	39 K, 1 2 w, Fixed, Comp., 10%	01121	EB 3931
R218	41-1.5 K	1.5 K, 1 2 w, Fixed, Comp., 10%	01121	EB 1521
R219 and R220	56-2.61 K	2.61 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-2.61 K
R221	71-91	500 Ω, Variable, 20 turn	96791	2600-500 Ω
R222	56-499 Ω	499 Ω, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-499 Ω
R223	56-100 K	100 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-100 K
R224		Same as R210		
R225		Same as R201		
R226		Same as R223		
R227	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1011
R228	42-8.2 K	8.2 K, 1 w, Fixed, Comp., 10%	01121	GB 8221
R229		Same as R215		
R301	41-100 Ω	100 Ω, 1 2 w, Fixed, Comp., 10%	01121	EB 1011
R302	56-1.96 K	1.96 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.96 K
R303	41-390 Ω	390 Ω, 1 2 w, Fixed, Comp., 10%	01121	EB 3911
R304	56-3.83 K	3.83 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-3.83 K
R305	56-7.50 K	7.50 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-7.50 K
R306	56-1.02 K	1.02 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TP-1.02 K
R307	56-19.6 K	19.6 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-19.6 K
R308	56-82.5 K	82.5 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-82.5 K
R309	71-93	10 K, Variable, 20 turn	96791	2600-20 K
R310	41-3.3 M	3.3 M, 1 2 w, Fixed, Comp., 10%	01121	EB 3351
R311	41-22 K	22 K, 1 2 w, Fixed, Comp., 10%	01121	EB 2231
R312		Same as R303		
R313	41-39 K	39 K, 1 2 w, Fixed, Comp.	01121	EB 3931
R314	71-92	20 K, Variable, 20 turn	96791	2600-20 K
R315		Same as R310		

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		RESISTORS (CON'T)		
R316	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%	01121	EB 563
R317	56-2.37 K	2.37 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-2.37 K
R318	56-1.33 K	1.33 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.33 K
R319	56-15 K	15 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-15 K
R320		Same as R302		
R321	56-14.7K	14.7K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-14.7 K
R401	43-2.2 K	2 .2 K, 2 w, Fixed, Comp., 10%	01121	HB 22
R402	43-15 K	15 K, 2 w, Fixed, Comp., 10%	01121	HB 15
R403	41-12 K	12 K, 1/2 w, Fixed, Comp., 10%	01121	EB 12
R404	41-33 K	33 K, 1/2 w, Fixed, Comp., 10%	01121	EB 33
R405 *	56-3.16 K	Factory Select nom. value 3.16 K	19701	MF-7C-TO-3.16 K
R406	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%	01121	EB 473
R407 and R408	42-3.3 M	3.3 M, 1 w, Fixed, Comp., 10%	01121	GB 3351
R409	43-10 K	10 K, 2 w, Fixed, Comp., 10%	01121	HB 103
R410	41-15 K	15 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1531
R901	61-22	8 M, 5000 v, Fixed	75042	MVG-13
R902		Not used		
R903	42-1 K	1 K, 1 w, Fixed, Comp., 10%	01121	GB 102
R904	43-68 K	68 K, 2 w, Fixed, Comp., 10%	01121	HB 6831
R905		Same as R903		
R906 and R907	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%	01121	EB 102
R908	41-47 Ω	47 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 470
R909		Same as R906		
R910	42-1.8 K	1.8 K, 1 w, Fixed, Comp.,10%	01121	GB 182
R911		Same as R906		
R912		Same as R908		
R913	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 10
R914		Not used		
R915	43-68 K	68 K, 2 w, Fixed, Comp., 10%	01121	HB 683
R916		Same as R913		
R917	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 220
R918	43-68 K	68 K, 2 w, Fixed, Comp., 10%	01121	HB 683
R919		Same as R917		
R920	43-27 Ω	27 Ω, 2 w, Fixed, Comp., 10%	01121	HB 270
R921	63-8	25 Ω, 20 w, Fixed, WW	35434	20J-25
R922	55-42	1.05 Ω, 1/2 w, Fixed, WW, 1%	91827	GZ-1.05 Ω
R923	71-41	5 K, Variable	73138	72PR5K
		NOTE: R924 thru R932 are mounted on a ceramic base aba... the fuse holder.		
R924	41-1 K	1 K, 1 2 w, fixed, Comp., 10%	01121	EB 102
R925	62-24	25 K, 10 w, Fixed, WW, 3%	91637	RS-10-25
R926	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MF-7C-TO-464 K
R927	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MF-7C-TO-464 K
R927	56-348 K	(560AC only) 348 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-348 K
R928	56-100 K	100 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-100 K
R925	56-71.5 K	(560AC only) 71.5 K, 1 2 w, Fixed, MF, 1%	19701	MF-7C-TO-71.5 K
R932	41-68 Ω	68 Ω, 1 2 w, Fixed, Comp., 10%	01121	EB 680
R933	41-100 Ω	100 Ω, 1 2 w, Fixed, Comp., 10%	01121	EB 10
R934 *		Factory select		
R936	42-18 K	18 K, 1 w, Fixed, Comp., 10%	01121	GB 1831
R937	41-4.7 K	4.7 K, 1 2 w, Fixed, Comp., 10%	01121	EB 472
R938	44-1.5 Ω	1.5 Ω, 1 2 w, Fixed, Comp., 5%	75042	BWH-1.5 Ω
		LAMPS		
DS401	126-1	Lamp, Neon, NE-2	08806	NE2
DS901 and DS902	126-9	Indicator Panel	95263	32-1111T
DS903	126-1	Lamp, Neon, Neon, NE-2	08806	NE2
		FUSES		
F901	121-3	Fuse, 3A, Type 3AG	75915	312003
F902	121-14	Fuse, 2 A, slo-blo, Type 3AG	75915	313002

*Factory Select

PARTS LIST - 560A/561A

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		RELAYS		
K901	106-3	DPDT, 6 v	77342	KA 1467
K902	106-19	3PDT, 6 v	77342	KA 14AY
K903	106-27	Time delay, 90 sec.	73445	6N060T
K904 and K905	106-24	SPDT, RS5D-10K	77342	RS-5D-10K
K906	106-13	DPDT, 6 v, DC	77342	PW 5257-1
		INDUCTORS		
L101 and L102	92-25	200 mh, choke, RF	76487	9210-90
L301	92-19	100 mh, coil, RF, 10%	71895	1025-68
		METERS		
M901	86-53	0 - 1 ma, 50 Ω, fullscale, 2%	06555	E-25E
		SWITCHES		
S901	101-3	Toggle	04009	81024 GB
S902	102-128	Lever	76854	233785-187-531F1-1SSA
S903	101-17	Interlock	01963	E33-20A
S904	101-22	Air Flow Interlock	01963	E51-07B
		TRANSFORMERS		
T901	91-191	AE950346C	17474	4-0740
T902	91-194	AE950380C	17474	4-0797
T903	91-192	AE950354C	17474	4-0754
T904	91-193	AE950378C	17474	4-0788
		VACUUM TUBES		
V901	111-0A2	Tube, electron, OA2	07029	OA2
V902	111-8068	Tube, electron, 8068	33173	8068
V903	111-7239	Tube, electron, 7239	33173	7239
V904	111-6GT5	Tube, electron, 6GT5	07029	6GT5
V905	TRAVELING WAVE TUBES FOR MODELS 560A, 561A			
	Model 560AC: SPEC. CONT. MEC M-4268K		03782	M-4268K
	Model 561AC: SPEC. CONT. MEC M-4260K		03782	M-4260K
V906		Same as V904		
		BLOWER ASSEMBLY		
B901	201-11	Blower	53404	3-90-8520

SECTION 5 - PARTS LIST

CHASSIS AND PC BOARD ASSEMBLIES
MODELS 562A/563A

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	SCHEMATIC
900 and 400		Main Chassis	D 900779-2
PC 100	901463	Low Voltage Anode Supply PC Board	C 900864-3
PC 200	901274	Low Voltage Supplies PC Board	C 900682
PC 300	950390	Heater and High Voltage Supply PC Board	C 900683

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		CAPACITORS		
C101 and C102	13-33	10 mf, Fixed, Elect., 100 v	56289	TE 1407
C103	14-13	1 mf, Fixed, Paper, 200 v	00656	P8292ZN13
C104	12-41	10 pf, Fixed, Cer., 1000 v	71590	DD 100
C105	12-3	.01 mf, Fixed, Cer., 1000 v,	71590	DA-049-211CB
C106	12-31	.022mf, fixed, elect., 1KV	56289	5-GAB-522
C107	12-13	.005 mf, Fixed, Cer., 500 v	71590	811-Z5V-502T
C201	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
C202	12-34	.1 mf, Fixed, Cer., 100 v	91418	BT 010
203 thru 205	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
206		Same as C202		
C207	13-40	100 mf, Fixed, Cer., 10 v	56289	TE 1119.3
C301	12-34	.1 mf, Fixed, Cer., 100 v,	91418	BT 010
C302		Not used		
C303		Same as C301		
C401	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
C402	13-21	20 mf, Fixed, Elect., 250 v	56289	TBA 1508
C403 thru C407		Not used		
C408	13-21	20 mf, Fixed, Elect., 250 v	56289	TVA 1508
C409		Not used		
C410	13-21	20 mf, Fixed, Elect., 250 v	56289	TVA 1508
C901 and C902	12-28	.001 mf, Fixed, Cer., 6000 v	71590	DD60-102
C903 and C904	15-18	2 mf, Fixed, Paper, 2000 v	99120	[illegible] 20-205
C905	15-20	1 mf, Fixed, Paper, 3000 v	99120	[illegible] 30-105
C906	12-30	1.5 pf, Fixed, Cer., 6000 v	56289	60-GA-V15
C907		Not used		
C908 thru C911	12-3	.01 mf, Fixed, Cer., 1000 v	71590	DA-049-211CB
C912 and C913	12-34	.1 mf, Fixed, Cer., 100 v	91418	BT [illegible]
C914	13-4	150 mf, Fixed, Elect., 150 v	56289	[illegible] 28978
C915	13-36	100 100 mf, Fixed, Elect., 50 v	56289	[illegible] 2826
C916	13-9	3000 mf, Fixed, Elect., 15 v	37942	MPC 42A
C917	13-4	Same as C914		
C918		Not used		
C919	16-5	.1 mf, Fixed, Plastic, 3000 v	99120	OF-30-104
		DIODES		
CR101 thru CR108	81-41	1N459	93332	1N459
CR201 and CR202	81-41	1N459	93332	1N459
CR203	81-75	Zener, 1N823 (6.2 v)	04713	[illegible]
CR301 and CR302	81-20	DI-46 1N4385	[illegible]	DI-46
CR303 and CR304	81-41	1N459	93332	1N459
		DIODES (CON'T)		
CR401	81-20	DI-46/1N4385	12060	DI-46
CR402	81-57	Zener, 1/4 M15Z10	04713	[illegible]
CR403 and CR404		Not used		
CR405		Same as CR401		
CR406 thru CR408		Not used		
CR409		Same as CR401		
CR901 A, B	81-69	H. V. Rectifier DI-1154	[illegible]	[illegible]
CR902 and CR903		Not used		
CR904 thru CR907	81-20	DI-46 1N4385	12060	DI-46
CR908 and CR909	81-93	MR322R	04713	[illegible]
CR910		Same as CR904		
CR911	81-125	1N4756	04713	[illegible]
CR912	81-77	Zener 1N752A, 18199	99942	[illegible]
CR913 thru CR918		Not used		
CR919 and CR920	81-41	1N459	93332	[illegible]
		TRANSISTORS		
[illegible]		[illegible]		
[illegible]	81-114	2N3638A	[illegible]	[illegible]
[illegible]	81-72	2N699	[illegible]	[illegible]
[illegible]		Same as [illegible]		
[illegible]	81-129	2N3645	[illegible]	[illegible]
[illegible]	81-7	2N697	[illegible]	[illegible]
Q108 and Q109		Same as Q104		
Q201	81-51	2N404	[illegible]	[illegible]
Q202	81-72	2N699	[illegible]	[illegible]
Q203 and Q204		Same as Q201		
Q205 and Q206	81-73	2N706	07029	[illegible]
Q207		Not used		
Q208		Same as Q202		
Q209 and Q210		Same as Q201		
Q211 and Q212		Same as Q205		
[illegible]	81-72	2N699	[illegible]	[illegible]
[illegible] and [illegible]	81-5	2N404	[illegible]	[illegible]
[illegible]		2N3860	[illegible]	[illegible]
[illegible] and [illegible]		Same as Q301		

*Factory Select

PARTS LIST - 562A/563A

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		TRANSISTORS (CON'T)		
Q401 and Q402	81-72	2N699	96214	2N699
Q901	81-112	40251	07029	40251
Q902	81-86	2N2147	07029	2N2147
Q903	81-74	2N1540	04713	2N1540
Q904	81-71	2N697	96214	2N697
		RESISTORS		
R101	56-7.5 K	7.5 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-7.5 K
R102	56-1 K	1 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1 K
R103	41-560 K	560 K, 1/2 w, Fixed, Comp., 10%	01121	EB 5641
R104	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-19.6 K
R105	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-14.7 K
R106	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-3.83 K
R107	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-16.2 K
R108	56-31.6 K	31.6 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-31.6 K
R109	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%	01121	EB 5631
R110	41-100 K	100 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1041
R111	56-46.4 K	46.4 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-46.4 K
R112		Same as R110		
R113	43-2.2 K	2.2 K, 2 w, Fixed, Comp., 10%	01121	HB 2221
R114		Same as R110		
R115		Same as R103		
R116	56-26.1 K	26.1 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-26.1 K
R117	56-53.6 K	53.6 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-53.6 K
R118	41-15 K	15 K, 1/2 w, Fixed, Comp., 10%	001121	EB 1531
R119	71-93	10 K, Variable, 20 turn	96791	2600 - 10 K
R120	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.96 K
R121	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1031
R122 *	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%	01121	EB 3351
R123	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%	01121	EB 4731
R124	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1001
R125	43-3.3 K	3.3 K, 2 w, Fixed, Comp., 10%	01121	GB 3321
R126	56-10 K	10 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-10 K
R127	56-4.99 K	4.99 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-4.99 K
R128	56-52.3 K	52.3 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-52.3 K
R129		Same as R121		
R130	43-15 K	15 K, 2 w, Fixed, Comp., 10%	01121	GB 1531
R131	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1011
R132		Same as R123		
R201	56-5.62 K	5.62 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-5.62 K
R202	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.96 K
R203	56-7.50 K	7.50 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-7.50 K
R204	56-10 K	10 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-10 K
R205	41-8.2 K	8.2 K, 1/2 w, Fixed, Comp., 10%	01121	EB 8221
R206	42-1 K	1 K, 1 w, Fixed, Comp., 10%	01121	GB 1021
R207	41-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1521
R208	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1031
R209	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%	01121	EB 2231
R210	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 2201
R211	41-68 K	68 K, 1/2 w, Fixed, Comp., 10%	01121	EB 6831
R212		Same as R209		
R213	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-16.2 K
R214	56-4.64 K	4.64 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-4.64 K
R215	44-1.0 Ω	1.0 Ω, 1/2 w, Fixed, Comp., 5%	75042	BWH - 1.0 Ω
R216	43-1 K	1 K, 2 w, Fixed, Comp., 10%	01121	HB 1021
R217	41-39 K	39 K, 1/2 w, Fixed, Comp., 10%	01121	EB 3931
R218		Same as R207		
R219 and R220	56-2.61 K	2.61 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-2.61 K
R221	71-91	500 Ω, Variable, 20 turn	96791	2600 - 500 Ω
R222	56-499 Ω	499 Ω, 1/2 w, Fixed, MF	19701	MF-7C-TO-499 Ω
R223	56-100 K	100 K, 1/2 w, Fixed, MF	19701	MF-7C-TO-100 K
R224		Same as R210		
R225		Same as R201		
R226		Same as R223		
R227	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1011
R228	42-8.2 K	8.2 K, 1 w, Fixed, Comp., 10%	01121	GB 8221
R229		Same as R215		

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		RESISTORS (CON'T)		
R301	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1011
R302	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 10%	19701	MF-7C-TO-1.96 K
R303	41-390 Ω	390 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 3911
R304	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-3.83 K
R305	56-7.50 K	7.50 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-7.50 K
R306	56-1.02 K	1.02 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.02 K
R307	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-19.6 K
R308	56-82.5 K	82.5 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-82.5 K
R309	71-93	10 K, Variable 20 turn	96791	2600-10 K
R310	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%	01121	EB 3351
R311	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%	01121	EB 2231
R312		Same as R303		
R313	41-39 K	39 K, 1/2 w, Fixed, Comp., 10%	01121	EB 3931
R314	71-92	20 K, Variable, 20 turn	96791	2600 - 20 K
R315		Same as R310		
R316	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%	01121	EB 5631
R317	56-2.37 K	2.37 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-2.37 K
R318	56-1.33 K	1.33 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-1.33 K
R319	56-15 K	15 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-15 K
R320		Same as R302		
R321	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-14.7 K
R401	43-2.2 K	2.2 K, 2 w, Fixed, Comp., 10%	01121	HB 2221
R402	43-15 K	15 K, 2 w, Fixed, Comp., 10%	01121	HB 1531
R403	41-12 K	12 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1231
R404	41-33 K	33 K, 1/2 w, Fixed, Comp., 10%	01121	EB 3331
R405 *	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-3.83 K
R406	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%	01121	EB 4731
R407 and R408		Not used		
R409		Same as R401		
R410	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1011
R901 and R902	61-22	8 M, 5000 v, Fixed	75042	MVG-13
R903	42-1 K	1 K, 1 w, Fixed, Comp., 10%	01121	GB 4221
R904	43-68 K	68 K, 2 w, Fixed, Comp., 10%	01121	HB 6831
R905		Same as R903		
R906 and R907	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1021
R908 thru R912		Not used		
R913	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1001
R914		Not used		
R915	43-68 K	68 K, 2 w, Fixed, Comp., 10%	01121	HB 6831
R916		Same as R913		
R917	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 2201
R918	43-68 K	68 K, 2 w, Fixed, Comp., 10%	01121	HB 6831
R919		Same as R917		
R920	43-27 Ω	27 Ω, 2 w, Fixed, Comp., 10%	01121	HB 2701
R921	63-8	25 Ω, 20 w, Fixed, WW	35434	C20 - 25
R922	55-42	1.05 Ω, 1/2 w, Fixed, WW, 1%	91827	G2-1.05 Ω
R923	71-41	5 K, Variable,	44655	CU 5021
		NOTE: R924 thru R932 are mounted on a ceramic board above the fuse holder.		
R924	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1021
R925	62-24	55 K, 10 w, Fixed, WW, 3%	91637	RS-10-55 K
R926	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MFS-1-T2-464 K
R927	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MFS-1-T2-464 K
R928	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MFS-1-T2-464 K
R929	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MFS-1-T2-464 K
R930	52-464 K	464 K, 1 w, Fixed, MF, 1%	19701	MFS-1-T2-464 K
R931	56-118 K	118 K, 1/2 w, Fixed, MF, 10%	19701	MF-7C-TO-118 K
R931 **	52-464 K	(for 563AC only) 464 K, 1 w, Fixed, MF, 1%	19701	MFS-1-T2-464 K
R932	41-68 Ω	68 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 6801
R932 **	56-215 K	215 K, 1/2 w, Fixed, MF, 1%	19701	MF-7C-TO-215 K
R933	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 1011
R934	41-68 Ω	68 Ω, 1/2 w, Fixed, Comp., 10%	01121	EB 6801
R935	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%	01121	EB 1031
R936		Not used		
R937	41-4.7 K	4.7 K, 1/2 w, Fixed, Comp., 10%	01121	EB 4721
R938	44-1.5 Ω	1.5 Ω, 1/2 w, Fixed, Comp., 5%	75042	BWH-1.5 Ω

*Factory Select

** for Model 563A only

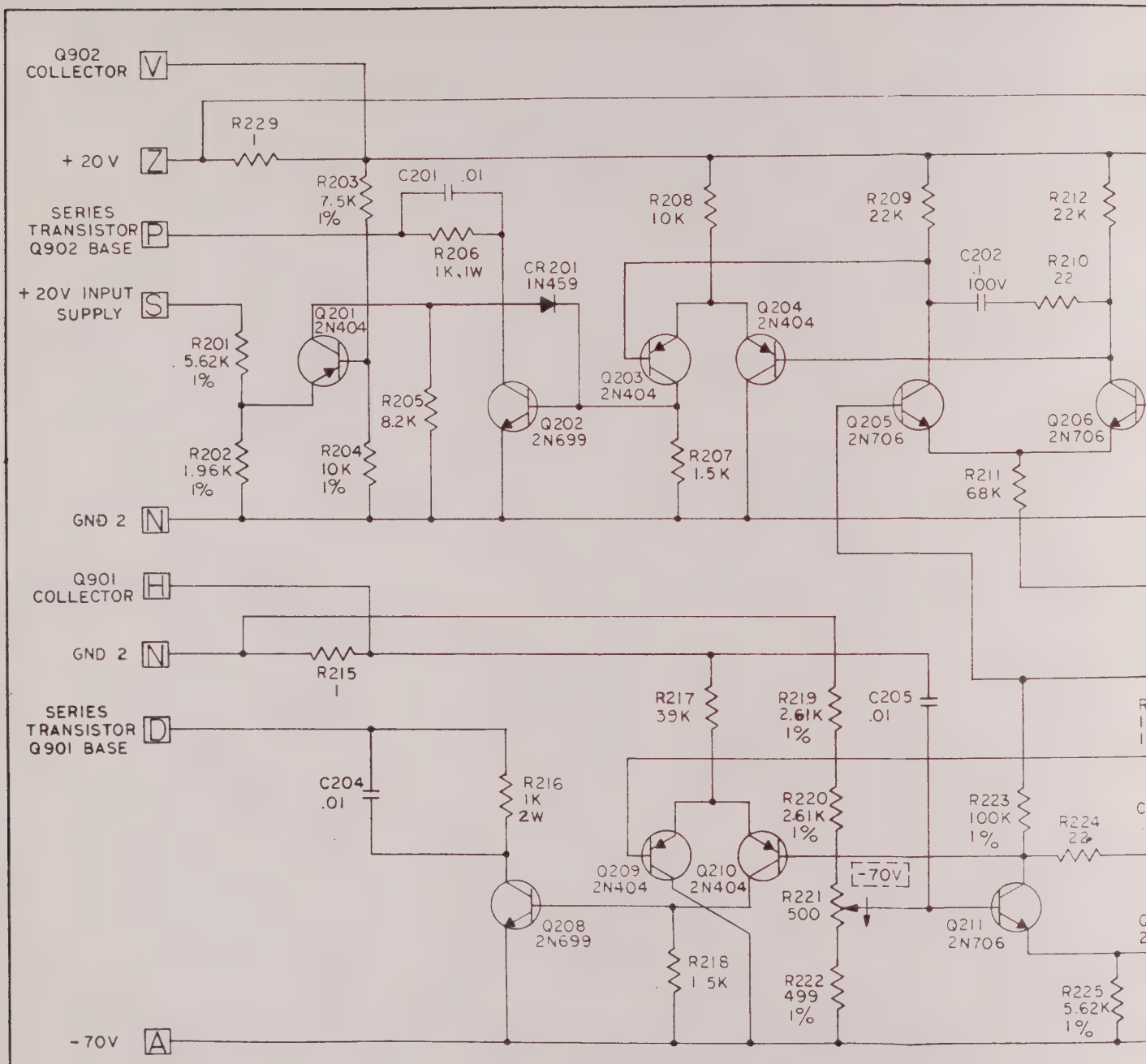
PARTS LIST - 562A/563A

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION	TRUE MFR.	TRUE MFR. PART NO.
		LAMPS		
DS401	126-1	Lamp, Neon NE-2	08806	NE-2
DS901 and DS902	126-9	Indicator Panel	95263	32-1111T
		FUSES		
F901	121-3	Fuse, 3 A Type 3AG	75915	312003
F902	121-14	Fuse, 2 A, Type 3AG slo-blo	75915	313002
		RELAYS		
K901	106-3	DPDT, 6 v, AC	77342	KA 1467
K902	106-19	3PDT, 6 v	77342	KA 14AY
K903	106-27	Time Delay, 90 sec.	73445	6N060T
K904 and K905	106-24	SPDT, RS5D-10 K	77342	RS-5D-10K
K906	106-13	DPDT, 6 v, DC	77342	PW 5257-1
		INDUCTORS		
L301	92-19	100 mf, coil, RF, 10%	71895	1025-68
		METERS		
M901	86-53	0 - 1 ma, 50 Ω, full scale, 2%	06555	E-25E
		SWITCHES		
S901	101-3	Toggle	04009	81024 GB
S902	102-128	Lever	76854	233785-187-53F1, ISS A
S903	101-17	Interlock	01963	E33-20A
S904	101-22	Airflow Interlock	01963	E51-07B
		TRANSFORMERS		
T901	91-191	AE 950346C	17474	4-0740
T902	91-194	AE 950380C	17474	4-0797
T903	91-192	AE 950354C	17474	4-0754
T904	91-193	AE 950378C	17474	4-0788
		VACUUM TUBES		
V901	111-OA2	Tube, electron, OA2	07029	OA2
V902	111-8068	Tube, electron, 8068	33173	8068
V903	111-7239	Tube, electron, 7239	33173	7239
V905	TRAVELING WAVE TUBES FOR MODELS 562A 563A			
	Model 562AC: SPEC. CONT. MEC M-4278K		03782	M-4278K
	Model 563AC: SPEC. CONT. MEC M-4273K		03782	M-4273K
		BLOWER ASSEMBLY		
B901	201-11	Blower	53404	3-90-8520

LIST OF FSC CODES FOR TRUE MFRS.

FSC Number (if available)	Full Name and Address of Vendor
00656	Aerovox Corporation, 740 Belleville Ave., New Bedford, Mass.
00816	Hughes Aircraft Co., Vacuum Div., 500 Superior Ave., Newport Beach, Calif
00853	Sangamo Electric Co., P.O. Box 128, Pickens, S.C.
00866	Goe Engineering Co., 219-21 S. Mednik Ave., Los Angeles, Calif.
01121	Allen Bradley Co., 136 W. Greenfield Ave., Milwaukee, Wisc.
01963	Cherry Electrical Products Corp., Box 439, Highland Park, Ill.
03565	Dayton Electronic Products Co., 117 E. Helena St., Dayton, Ohio
03782	Alfred Electronics, 3176 Porter Drive, Palo Alto, Calif.
04009	Arrow-Hart, & Hegeman Elec. Co., 113 Hawthorne St., Hartford, Conn.
04713	Motorola Semiconductor Prod., Inc., P.O. Box 955, Phoenix, Ariz.
05783	Stewart Engineering Co., 467 Bean Creek Rd., Santa Cruz, Calif.
05820	Wakefield Engineering Inc., 139-T Foundry St., Wakefield, Mass.
06555	Beede Electrical Instrument Co., Inc., Penacock, N.H.
06980	Varian, 611 Hansen Way, Palo Alto, Calif. (BWO)
07029	Radio Corp. of America, Electronic Components & Devices, 415 S. 5th St. Harrison, New Jersey
07137	Transistor Electronics Corp., Box 6191, Minneapolis, Minn.
07263	Fairchild Semiconductor, 545 Whisman Rd., Box 880, Mountain View, Calif.
08806	General Electric Corp., Min. Lamp Dept., Nela Park, Cleveland, Ohio
09022	Cornell-Dubilier, 50 Paris St., Newark, N.J. (Mica Caps)
09023	Cornell-Dubilier, 50 Paris St., Newark, N.J. (Electrolytic Caps)
09297	CP Electronics Inc., Columbus, Ind.
11312	Microwave Electronics Div. of Teledyne, 3165 Porter Dr. Palo Alto, Calif.
12060	Diodes, Inc., 9261 Independence Ave., Chatsworth, Calif.
12697	Clarostat Mfg. Co., Washington St., Dover, N.H.
13862	Alasco Rubber and Plastics Corp., 839 Malcom Rd., Burlingame, Calif.
14433	International Telephone and Telegraph, 3301 Electronic Way, W. Palm Beach, Florida
14482	Watkins-Johnson Co., 3333 Hillview, Palo Alto, Calif.
15582	Bay City Screw and Bolt Co., 601 Industrial Way, San Carlos, Calif.
16741	Triad Dist. Div. (Litton Ind.) 305 N. Briant St. Huntington, Ind.
17474	Tranex, Inc., 1599 Stierlin Rd., Mountain View, Calif.
17920	Warnecke Electron Tubes, 175 W. Oakton St., Des Plaines, Ill.
18489	Reliable Capacitors Co., 14716 Arminta St., Van Nuys, Calif.
18915	Birtcher Corp., The Industrial Div., 745 S. Monterey Pass Rd., Monterey Park, Calif.
19701	Electra Mfg. Co., 800 North 21, Independence, Kansas
20286	Daytron, Inc., 1269 Terra Bella, Mountain View, Calif.
20649	Universal Metal Products, 5924 N. Western Ave., Chicago 45, Ill.
21030	Beckman Instrument, Inc., Helipot Div., 2500 Harbor Blvd., Fullerton, Calif.
21743	Canseat Corp., 4164 Greenbush Ave., Sherman Oaks, Calif.
23880	Standford Applied Engineering, 340 Martan Ave., Santa Clara, Calif.
28480	Hewlett-Packard, Paeco Div., 3215 Porter Dr., Palo Alto, Calif.
33173	General Electric Corp., Tube Dept., 316 E. Ninth St., Owenboro, Ky.
35434	Lectrohm, Inc., 5560 Northwest Hwy., Chicago, Ill.
37942	Mallory Capacitor Co., Div. P.R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis, Ind.
42190	The Meter Co., 1255 S. Michigan Ave., Chicago 5, Ill.
44655	Ohmite Mfg. [illegible]
46384	Penn Engineering, West State St., Doylestown, Penn.
56289	Sprague Electric Co., 81 Marshall St., N. Adams, Mass.
58474	C[illegible] Thomas & Betts Co., 843 Pierce St., San Francisco, Calif.

FSC Number (if available)	Full Name and Address of Vendor
71468	Allied Control Co., Inc., 2 East End Ave., New York, N.Y.
71450	CTS Corp., 1372 W. Beardsley, Elkhart, Ind.
71590	Centralab, Electronics Div., Globe Union, 934 Keefe Ave., Milwaukee, Wisc.
71785	Cinch Mfg. Co., 1026 S. Homan Ave., Chicago 24, Ill.
71895	Delavan Mfg. Co., Electro-Sonics Div., West Des Moines, Iowa
71982	Erie Technological Products, Inc., 644 W. 12th St., Erie, Penn.
72012	M. Ducommun Mfg. Co., 580 Fifth Ave., New York 36, N.Y.
72136	Electro Motive Mfg. Co., Inc., S. Park and John Streets, Willimantic, Conn.
72983	Stancor Electronics (Essex Wire Corp.) 3501 W. Addison St., Chicago [illegible]
73293	Hughes Aircraft Co., Elec. Comp. Div., 500 Superior Ave., Newport Beach, Calif.
73445	Amperex Electronic Corporation, Box 418, 230 Duffy Ave., Hicksville, N.Y.
73899	JFD Elect. Co., Comp. Div., 15th Ave. at 62nd St., Brooklyn, N.Y.
74542	Hoyt Electrical Inst. Works, Inc., 42 Carleton St., Cambridge, Mass.
74868	Amphenol Corp., Connector Div. 1830 S. 54th Ave., Chicago, Ill.
74970	The E.F. Johnson Co., 1923 10th Ave., S.W. Waseca, Minn.
75376	Kurz Kasch, 1417 S. Broadway, Dayton, Ohio
75382	Kulka Electric Corp., 520 S. Fulton Ave., Mt. Vernon, N.Y.
75042	IRC, Inc., 401 N. Broad St., Philadelphia, Penn.
75497	Lamson & Sessions, 5002 Tiedeman Rd., Cleveland, Ohio
75915	Littelfuse, Inc., 800 E. Northwest Hwy., Des Plaines, Ill.
76433	General Instrument Corp., 65 Gouverneur, Newark, N.J.
76487	James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77342	Potter & Brumfield, Div. American Machine & Foundry Co., [illegible]
77551	Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland, Ohio
78553	Tinnerman Co., Dept. 16-T, P.O. Box 6688, Cleveland, Ohio
81073	Grayhill, Inc., 569 Hillgrove Ave., La Grange, Ill.
81312	Winchester Electronics, Inc., Div. Litton Industries, 19 Willard[illegible]
82389	Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.
82647	USECO, Div. of Litton Industries, 13536 Saticoy St., Van Nuys
83058	John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Wash.
83салф	Stoesser Tool and Die, 3366 Fayette Dr., Mountain View, Calif.
84411	Radio Materials Co., 4242 W. Bryn Mawr Ave., Chicago 46, Ill.
84907	Dale Electronics, Inc., (Subs. Lionel Corp.), Box 609, 1342 28th St., Columbus, Nebr.
84996	Harrison & Sonini, 1122 Harrison St., San Francisco, Calif.
91627	K & F Tool Die & Mfg. Inc., 1203 Dell Ave., Campbell, Calif.
93332	Sylvania Electric Products, Inc., Semiconductor Div., 100 Sylvan Rd. Woburn, Mass.
93389	Proto Stamping, Washington & Santa Fe, Los Angeles 54, Calif.
94375	Automatic Metal Products Corp., 323 Berry St., Brooklyn 11, N.Y.
95263	Leecraft Mfg. Co., Inc., 44-35 21st St., Dept. E, Long Island City, N.Y.
95354	Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, Ill.
95712	Weckesser Co., Inc., 4444 W. Irving Park, Chicago, Ill.
96214	Texas Instruments, Inc., Semiconductor-Components Div., Box 5012 [illegible] Texas.
96791	Borg Electronics, Div. Amphenol-Borg Electronics Corp., 12[illegible] Mass.
97464	Industrial Retaining Ring Co., 57 Cordier St., Irvington, N.J.
97702	Plastic Capacitors, Inc., 2620 N. Clybourn Ave., Chicago, Ill.
98291	[illegible] 611 Hansen Way, Palo Alto, Calif. (BWO)
98941	Hoffman Electronics Corp., Semiconductor Div., Box 471, El Monte, Calif.

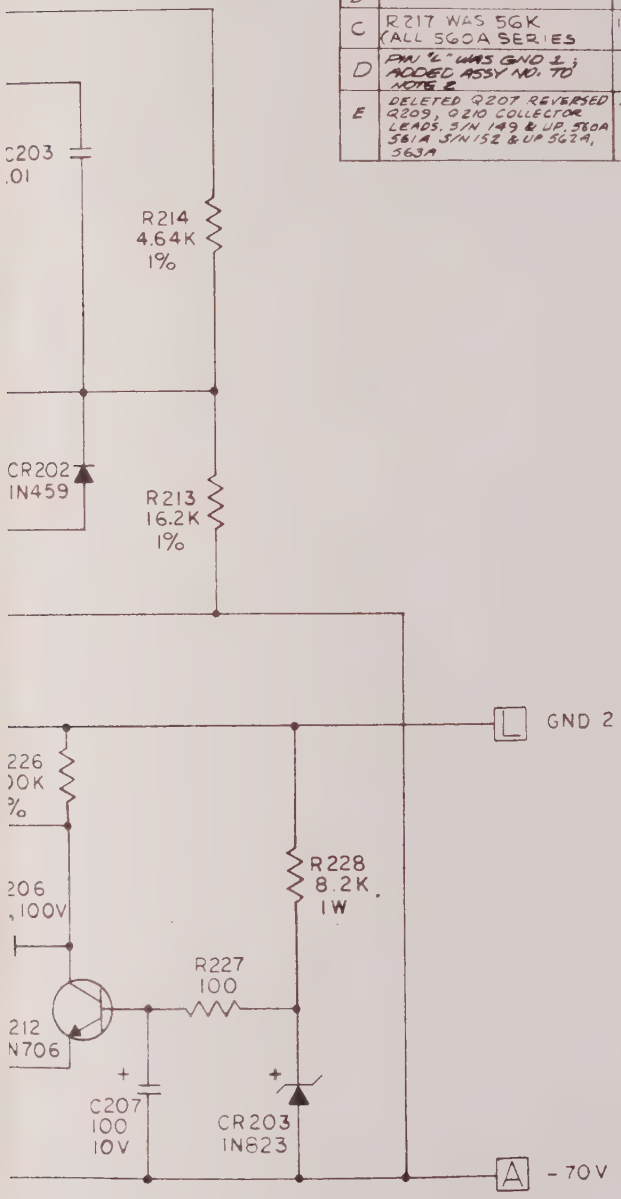


NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2 W, 10%.
   1B. ALL 1% RESISTORS ARE METAL FILM TYPE.
   1C. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON PC 200, ASSEMBLY NO. 901274

ITEM	REQD	PART NO
MATERIAL		DRAWN D.J. MA
MATERIAL STOCK NO		ENG
FINISH OR TREATMENT		PROD
		SCALE

SYM	DESCRIPTION	NO	DATE	BY
A	CR203 WAS IN752 R222 WAS 422Ω SER NO 41-UP	12434	6-5-64	DP
B	APPD FOR PRODUCTION	~	6-24-64	DP
C	R217 WAS 5GK (ALL 560A SERIES	12628	12-65	cg
D	PIN "L" WAS GND 1; ADDED ASSY NO. TO NOTE 2	~	22.5	RQ
E	DELETED Q207 REVERSED Q209, Q210 COLLECTOR LEADS. S/N 149 & UP. 560A 561A S/N 152 & UP 562A, 563A	12 8 4 8	10- 20- 65	M.S



S/N 152-UP	562A/563A
S/N 149-UP	560A/561A
NEXT ASSY	USED ON

DESCRIPTION

ST OF MATERIAL

KAIG DATE 2-2-64

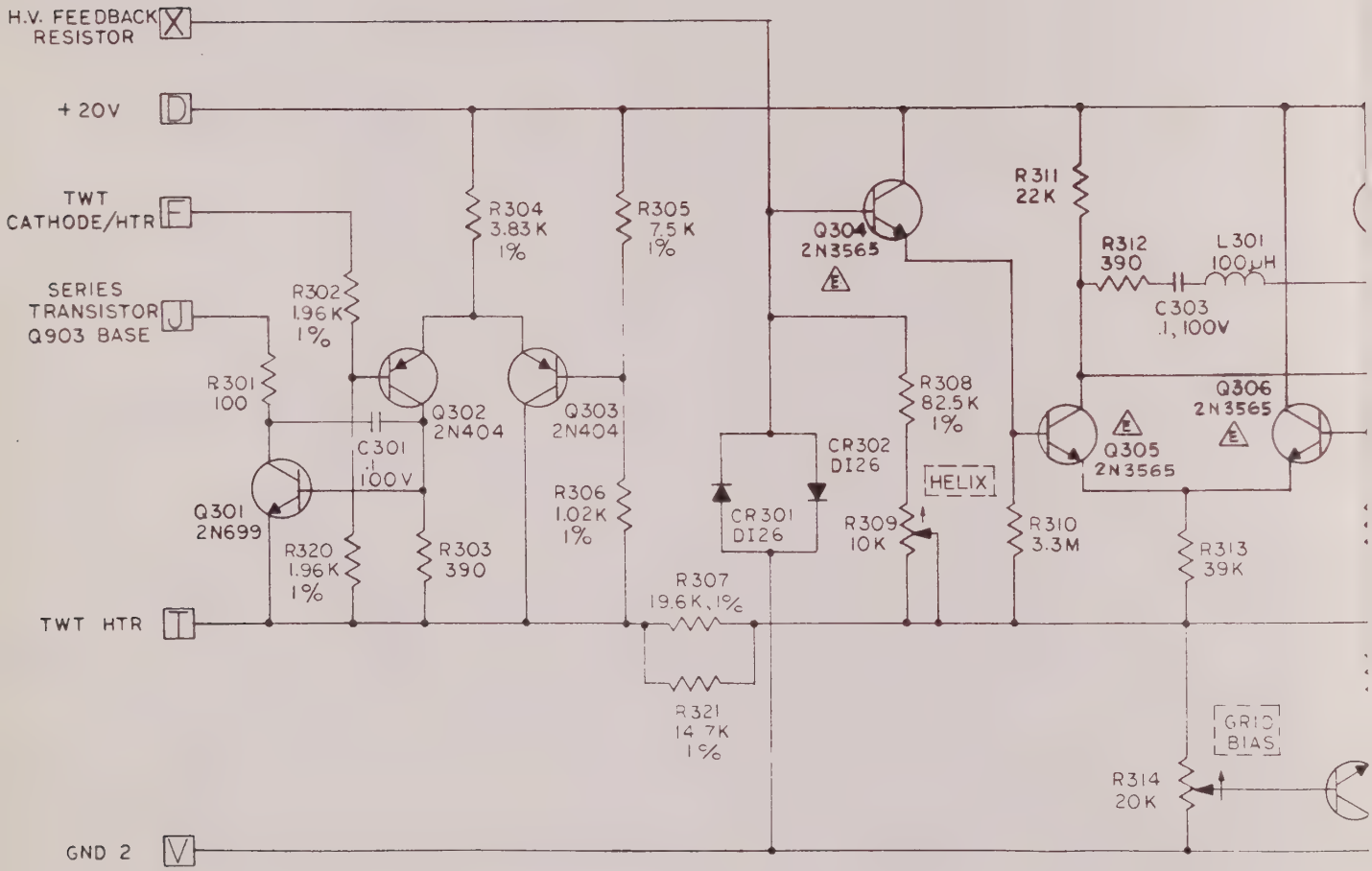
— SCHEMATIC —
LOW VOLTAGE SUPPLIES
(+20V & -70V)

DIMENSIONS ARE IN INCHES
TOL XX ± .015, XXX ± .005 ANGLE ± ½°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

900682C

SHEET 1 OF 1



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2 W, 10%.
   1B. ALL 1% RESISTORS ARE METAL FILM TYPE.
   1C. ALL CAPACITORS IN MICROFARADS, 500V.

2. SQUARE (□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON PC300, ASSEMBLY NO. 950390.

ITEM	REQD	PART NO	
			LIST

MATERIAL

MATERIAL STOCK NO

FINISH OR TREATMENT

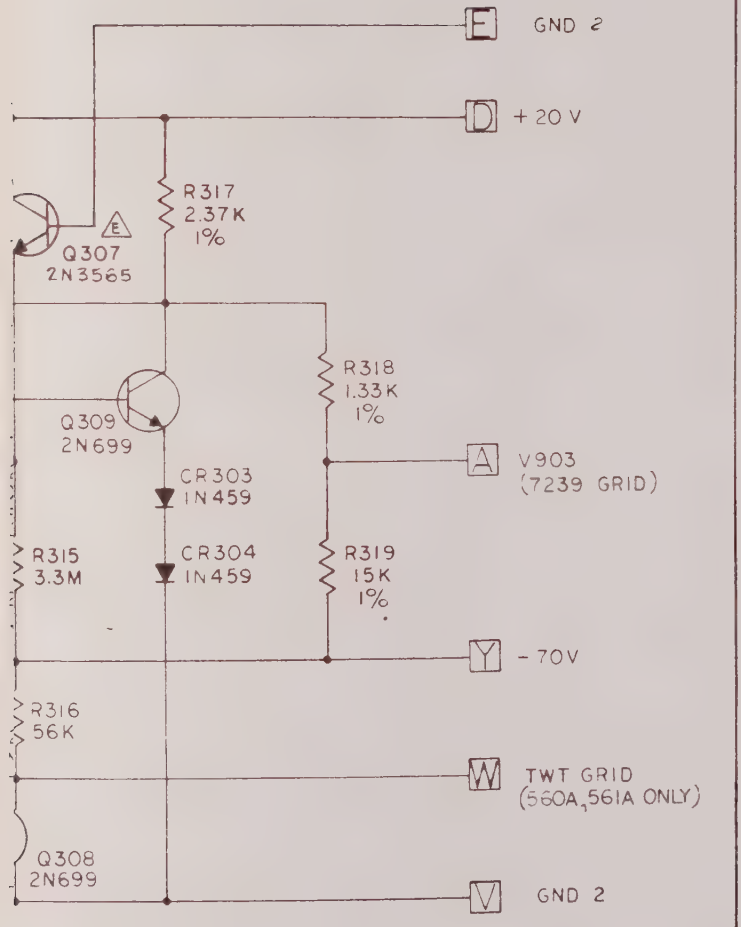
DRAWN D.J.MACK

ENG

PROD

SCALE

SYM	DESCRIPTION	NO	DATE	BY
A	R306 WAS 1.05K EFFECTIVE S/N 21-UP	12411	5-16-64	DP
B	ADDED FOR PRODUCTION	~	6-24-64	DP
C	DELETED C302 SER NO. 1-UP	12516	9-15-64	D.P
D	ADDED "5100A/561A ONLY" TO PART W	~	2-2-65	RQ
E	REVISED	13723	8/8/68	PMS



DESCRIPTION

OF MATERIAL

NEXT ASSY	USED ON
	560A SERIES

AIG | DATE

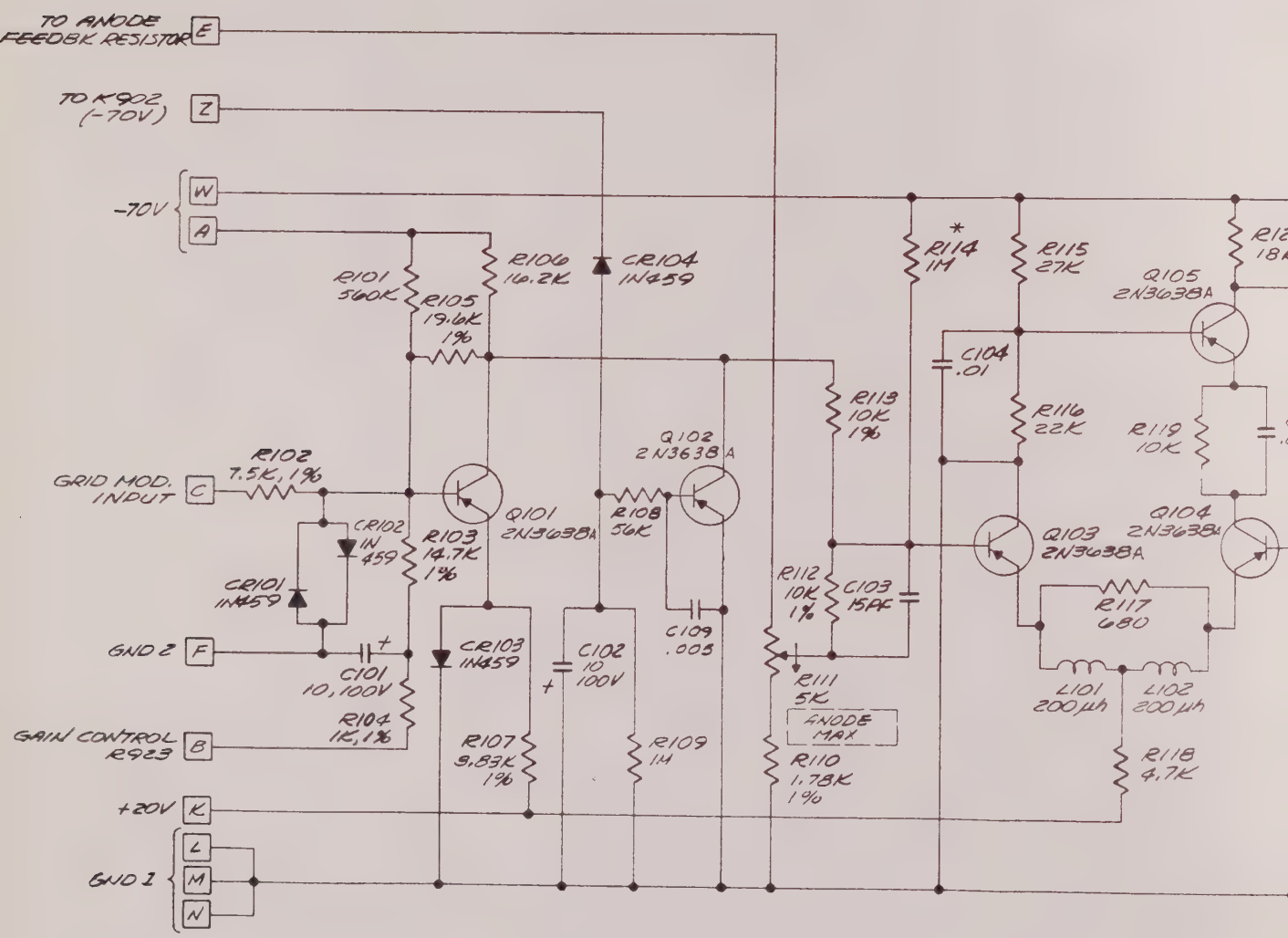
— SCHEMATIC —
HEATER & HIGH VOLTAGE SUPPLIES

ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

DIMENSIONS ARE IN INCHES
TOL XX ± .015 XXX ± .005 ANGLE ± ½°
UNLESS INDICATED OTHERWISE

SIZE C | 900683 | REV E

SHEET 1 OF 1



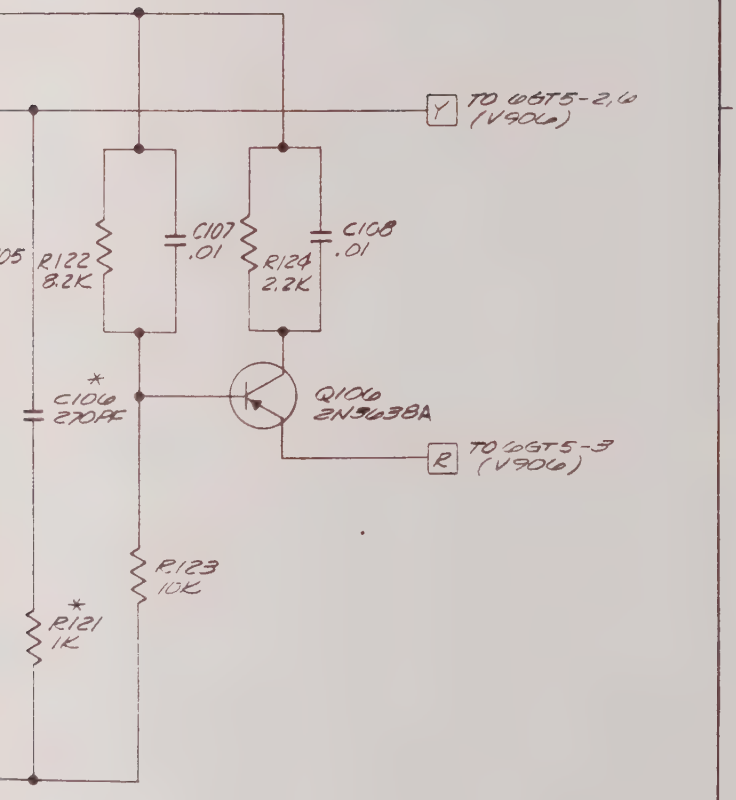
NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   - 1A. ALL RESISTORS IN OHM, 1/2W, 10%
   - 1B. ALL CAPACITORS IN MICROFARAD, 500V
   - 1C. ALL RESISTORS 1% ARE METAL FILM
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON ASSY "PC100", ASSEMBLY NO. 950891

* FACTORY SELECTED

ITEM	REQD	PART NO
MATERIAL		DRAWN
MATERIAL STOCK NO		ENG.
FINISH OR TREATMENT		PROD
		SCALE

SYM	DESCRIPTION	NO	DATE	BY
A	APPROVED FOR PROD. REPLACED 9006B1C	12598	1-8-65	[illegible]
	R120 WAS 22K, R102 WAS 10K, R108 WAS 220K, R109 WAS 1M. R114, A121, C106 MADE FACTORY SELECT S/N 130 & UP	12811	8-24-65	MS
B	ADDED C107 S/N 155 & UP	12812	9-1-65	MS
C	R109 WAS 100K. S/N 130 & UP	12811B	11-9-65	MS



45, 75 & UP	560AE
45, 75 & UP	561AC
45, 75 & UP	560AC
NEXT ASSY	USED ON

DESCRIPTION

OF MATERIAL

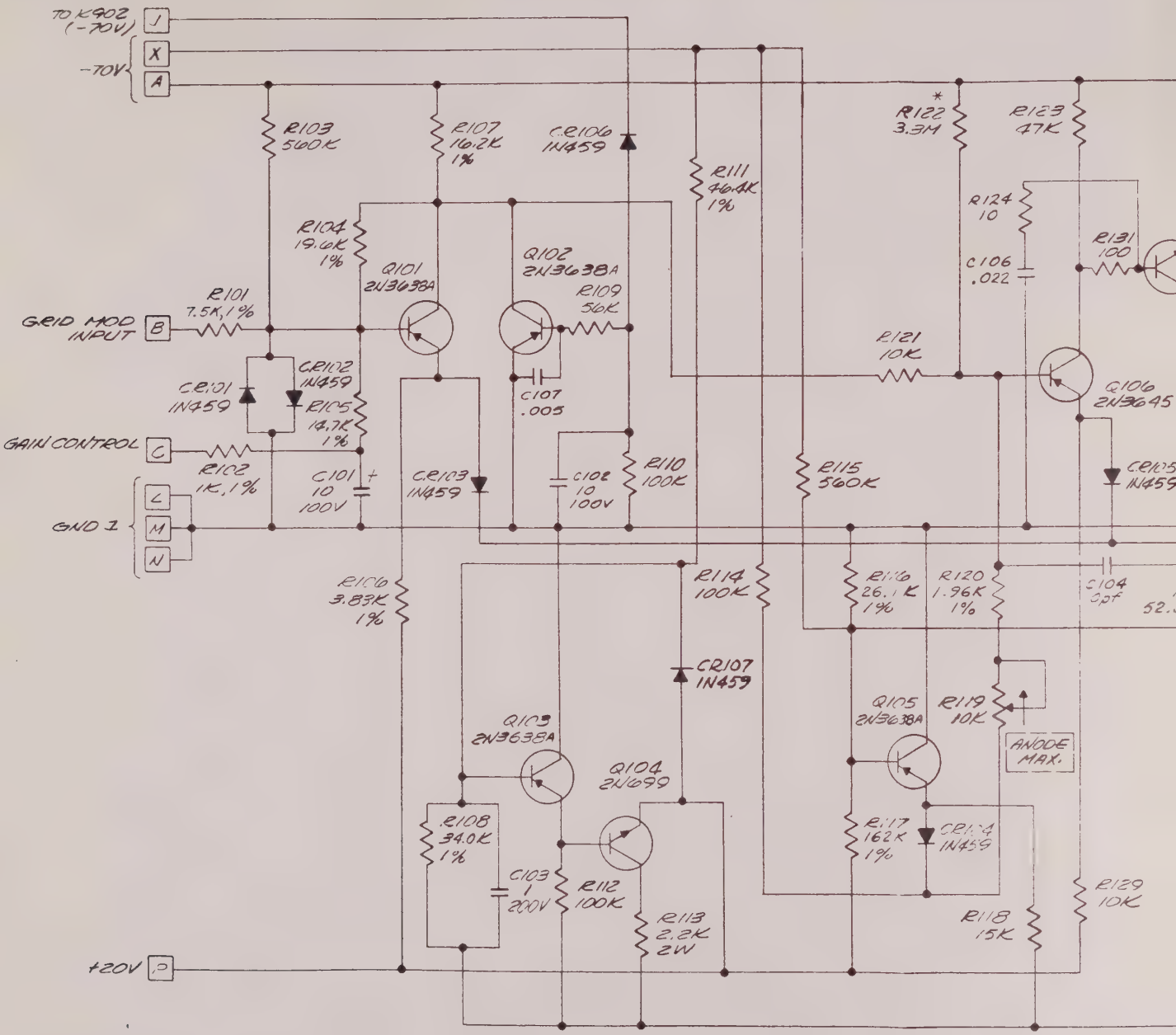
SCHEMATIC
HIGH VOLTAGE
ANODE SUPPLY

ALFRED ELECTRONICS
PALO ALTO CALIF.

DIMENSIONS ARE IN INCHES
TOL .XX ± 015 .XXX ± 005 ANGLE ± ½
UNLESS INDICATED OTHERWISE

9007780

SHEET 1 OF 1



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   - 1A. ALL RESISTORS IN OHMS, 1/2W, 10%
   - 1B. ALL CAPACITORS IN MICROFARADS, 500V
   - 1C. ALL RESISTORS 1% ARE METAL FILM
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON ASSY "PC100", ASSEMBLY NO. 901463

* FACTORY SELECTED.

ITEM	REQD	PART NO

LIST

MATERIAL

MATERIAL STOCK NO

FINISH OR TREATMENT

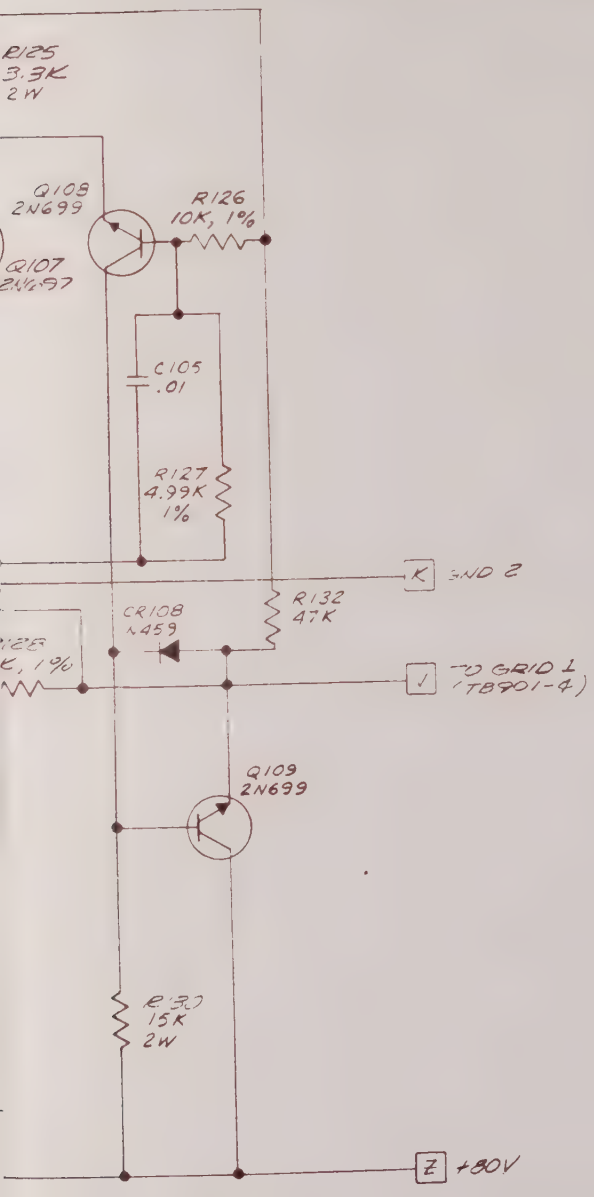
DRAWN

ENG

PROD

SCALE

SYM	DESCRIPTION	NO	DATE	BY
A	REPLACES 900780C	12983A	4-21-65	MS
B	R117 WAS 51.1K S/N181 & UP	12983B	5-9-65	MS
C	REFER TO ECO	12983C	7-8-65	MS
D	REPLACES 900864C-2	12983D	7-19-65	MS



181-UP	563AC
181-UP	562AC
NEXT ASSY	USED ON

DESCRIPTION

OF MATERIAL

	DATE
	1-8-65
	1-11-65

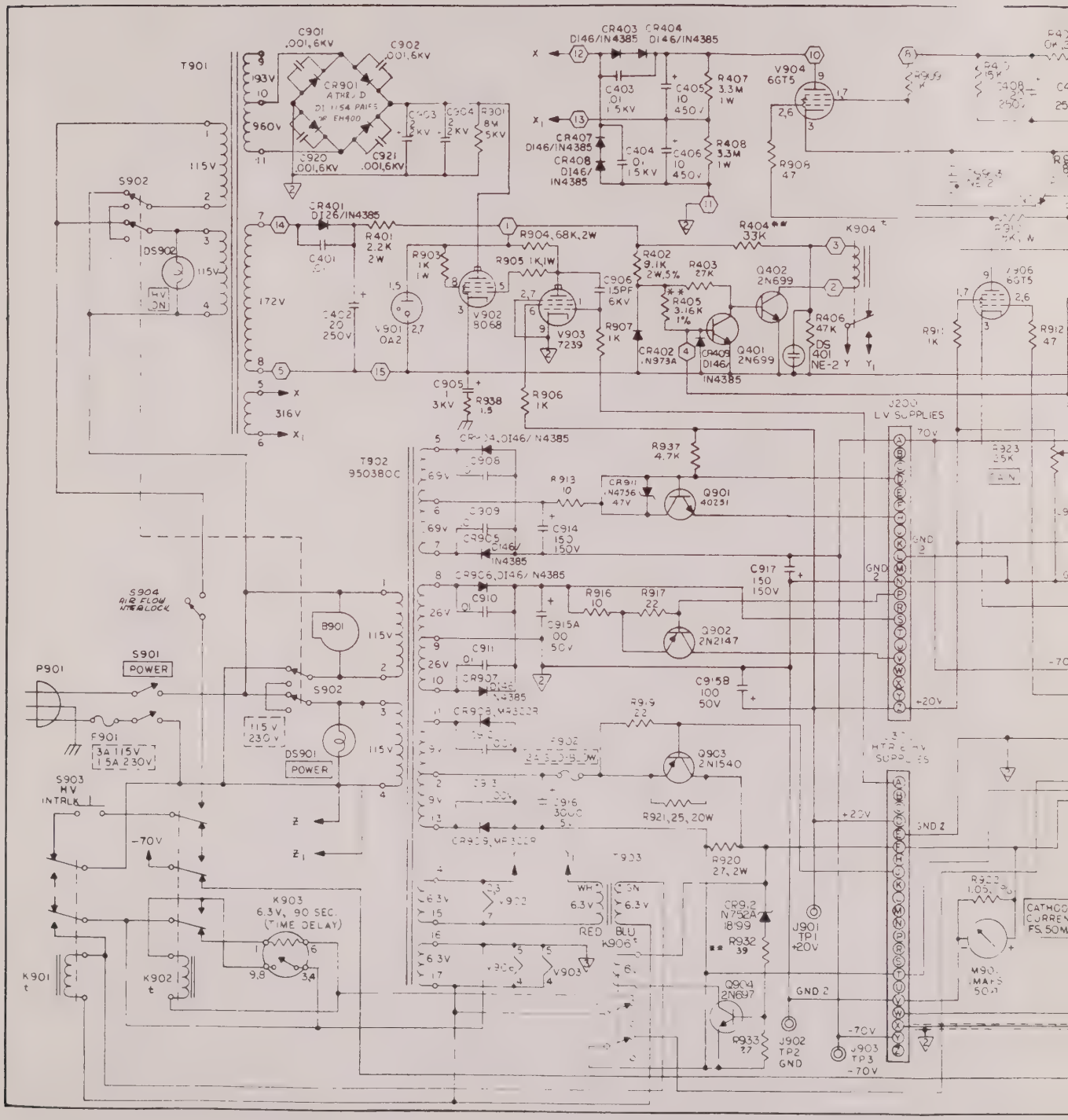
SCHEMATIC
LOW VOLTAGE
ANODE SUPPLY

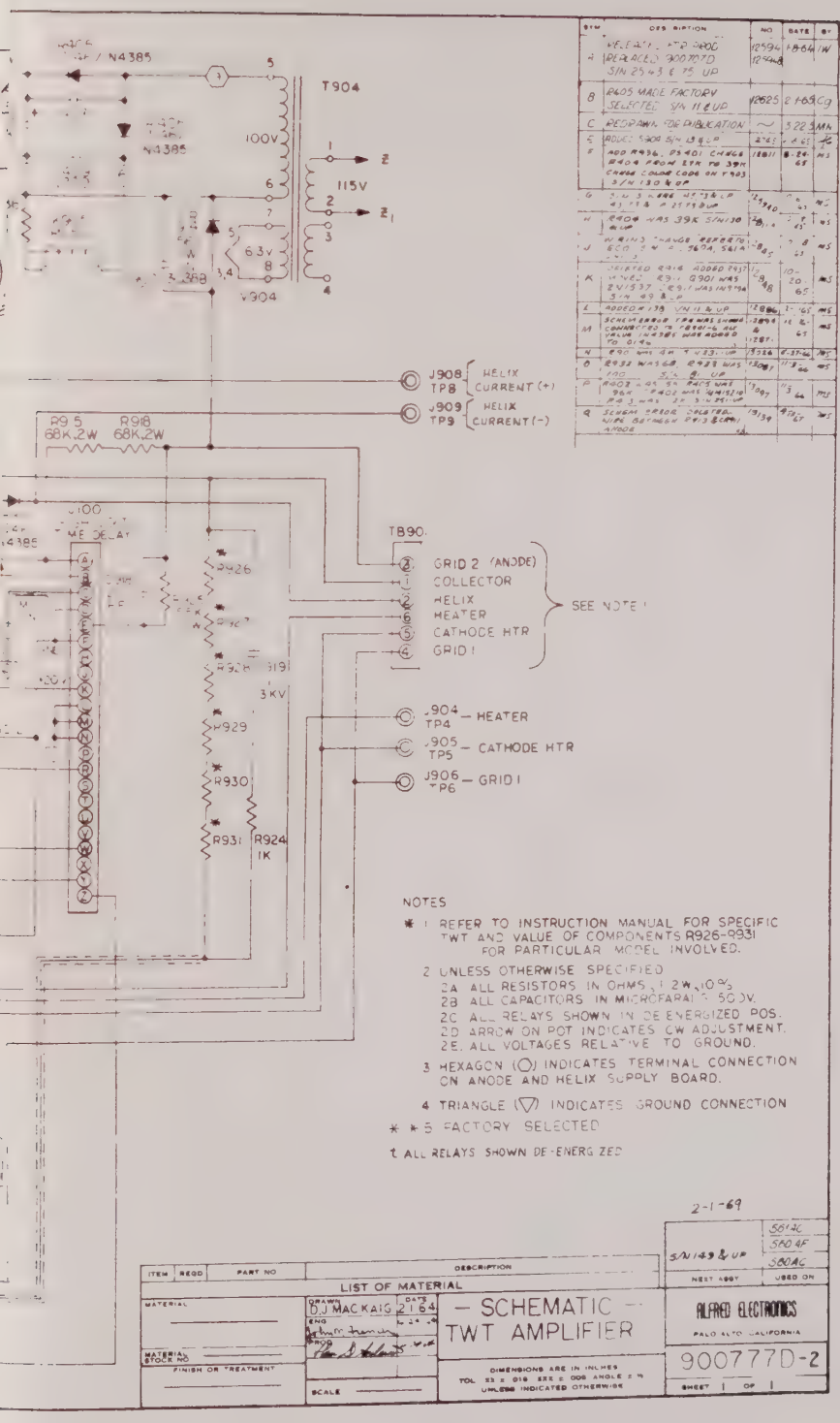
DIMENSIONS ARE IN INCHES
TOL XX ± 015 XXX ± 005 ANGLE ± ½°
UNLESS INDICATED OTHERWISE

ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

900864C-3

SHEET 1 OF 1


T901
C901 .001,6KV
C902 .001,6KV
CR901 A THRU D DI-1154 PAIES OR EH400
C903 .2 2KV
C904 .2 2KV
R301 8W 5KV
C920 .001,6KV
C921 .001,6KV
193V
960V
115V
S902
DS902
HV ON
172V
CR401 DI26/IN4385
R401 2.2K 2W
C401 .01
C402 20 250V
V901 0A2
R903 1K 1W
V902 9068
R905 1K,1W
R904 68K,2W
C905 3KV
R938 1.5
R906 1K
316V
CR403 CR404 DI46/IN4385
C403 .01 1.5KV
C405 10 450V
R407 3.3M 1W
CR407 DI46/IN4385
CR408 DI46/ IN4385
C404 .01 1.5KV
C406 10 450V
R408 3.3M 1W
V904 6GT5
R908 47
R404 33K
K904
C906 1.5PF 6KV
V903 7239
R907 1K
R402 9.1K 2W,5%
R403 27K
R405 3.16K 1%
CR402 1N973A
CR409 DI46/ IN4385
Q401 2N699
Q402 2N699
R406 47K
DS 401 NE-2
Y
Y1
T902 950380C
CR904,DI46/ N4385
C908 .69V
R913 10
CR911 1N4736 47V
Q901 40251
R937 4.7K
C909 .69V
C914 150 150V
CR905 DI46/ IN4385
CR906,DI46/ N4385
C910 .01 26V
R916 10
R917 22
Q902 2N2147
C915A .00 50V
C911 .01 26V
CR907 DI46/ IN4385
C915B 100 50V
CR908,MR3008
F902 3A 3AG SLO-BLO 3W
R919 22
Q903 2N1540
C916 3000 5V
CR909,MR3008
R921,25,20W
R920 27,2W
T903
K903 6.3V, 90 SEC. (TIME DELAY)
K901
K902
6.3V
WHT
RED
BLU
K906
CR9,2 1N752A 18.99V
R932 39
Q904 2N697
R933 27
J902 TP2 GND
J901 TP1 +20V
J903 TP3 -70V
J200 LV SUPPLIES
70V
GND 2
+20V
-70V
R923 1.05K
M90 1MA FS 50M
CATHOD CURREN
S904 AIR FLOW INTERLOCK
S901 POWER
P901
B901
115V
230V
F901 3A 115V 1.5A 230V
DS901 POWER
S903 HV INTRLK
-70V
Z
Z1
R912 47
R911 1K
R923 25K



SYM	DESCRIPTION	NO	DATE	BY
A	RELEASED PER PROC 900707D S/N 254 & UP	12594 12548	1-7-64	IW
B	R405 MADE FACTORY SELECTED S/N 11 & UP	12625	2-7-69	CG
C	REDRAWN FOR PUBLICATION	~	3-22-3	MN
E	ADDED S908 S/N 139 & UP	2745	6-8-65	AC
F	ADD R936, DS401 CHANGE R404 FROM 15K TO 39K CHANGE COLOR CODE ON T903 S/N 130 & UP	18811	8-24-65	MS
G	S/N 3 THRU 45 ADDED R937 & 25 TP8 & 25 TP9 BUS	24940	10-20-65	MS
H	R904 WAS 39K S/N 130 & UP	28111	10-20-65	MS
J	WIRING CHANGE REPORTED ECO S/N 3 THRU 360A, 561A	28827	10-20-65	MS
K	DELETED R916 ADDED R917 MOVED R911 TO R901 WAS 2W/1537 R911 WAS 1N3794 S/N 401 & UP	28948	10-20-65	MS
L	ADDED C179 S/N 11 & UP	28866	1-10-66	MS
M	SCHEMATIC ERROR TP8 WAS SHOWN CONNECTED TO R901-4.4K VALUE INCREASED TO .01M	28894 28981	12-8-65	MS
N	R901 WAS 4M S/N 233 & UP	33216	6-27-66	MS
O	R932 WAS 68 R933 WAS 470 S/N 5 & UP	33097	11-3-66	MS
P	R403 WAS 5% R405 WAS 96K R402 WAS 4M S/N 210 R933 WAS 2% S/N 251 UP	33097	11-3-66	MS
Q	SCHEM. ERROR DELETED WIRE BETWEEN PIN 3 ECON1 & ANODE	33139	4-17-67	MS

NOTES

* 1 REFER TO INSTRUCTION MANUAL FOR SPECIFIC TWT AND VALUE OF COMPONENTS R926-9931 FOR PARTICULAR MODEL INVOLVED.

2 UNLESS OTHERWISE SPECIFIED
- 2A ALL RESISTORS IN OHMS, ± 2W, ±10%
- 2B ALL CAPACITORS IN MICROFARADS 50 DV.
- 2C ALL RELAYS SHOWN IN DE-ENERGIZED POS.
- 2D ARROW ON POT INDICATES CW ADJUSTMENT.
- 2E ALL VOLTAGES RELATIVE TO GROUND.

3 HEXAGON (⬡) INDICATES TERMINAL CONNECTION ON ANODE AND HELIX SUPPLY BOARD.

4 TRIANGLE (▽) INDICATES GROUND CONNECTION

* * 5 FACTORY SELECTED

† ALL RELAYS SHOWN DE-ENERGIZED

2-1-69

S/N 149 & UP	560-C
	560-F
NEXT ASSY	560-G USED ON

ITEM	REQD	PART NO	DESCRIPTION

LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO

FINISH OR TREATMENT

DRAWN DJ MACKAIG DATE 2/64

ENG

SCALE

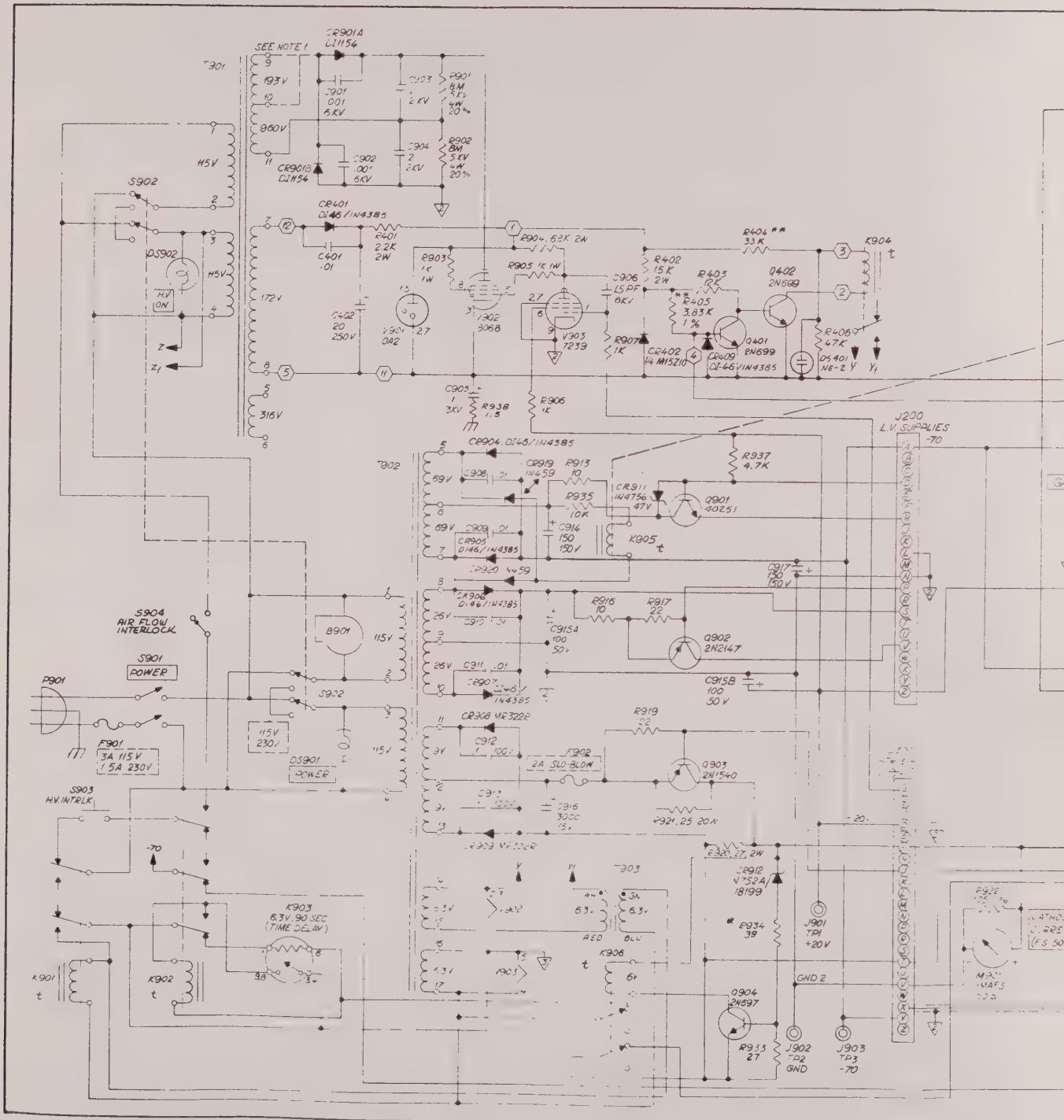
— SCHEMATIC — TWT AMPLIFIER

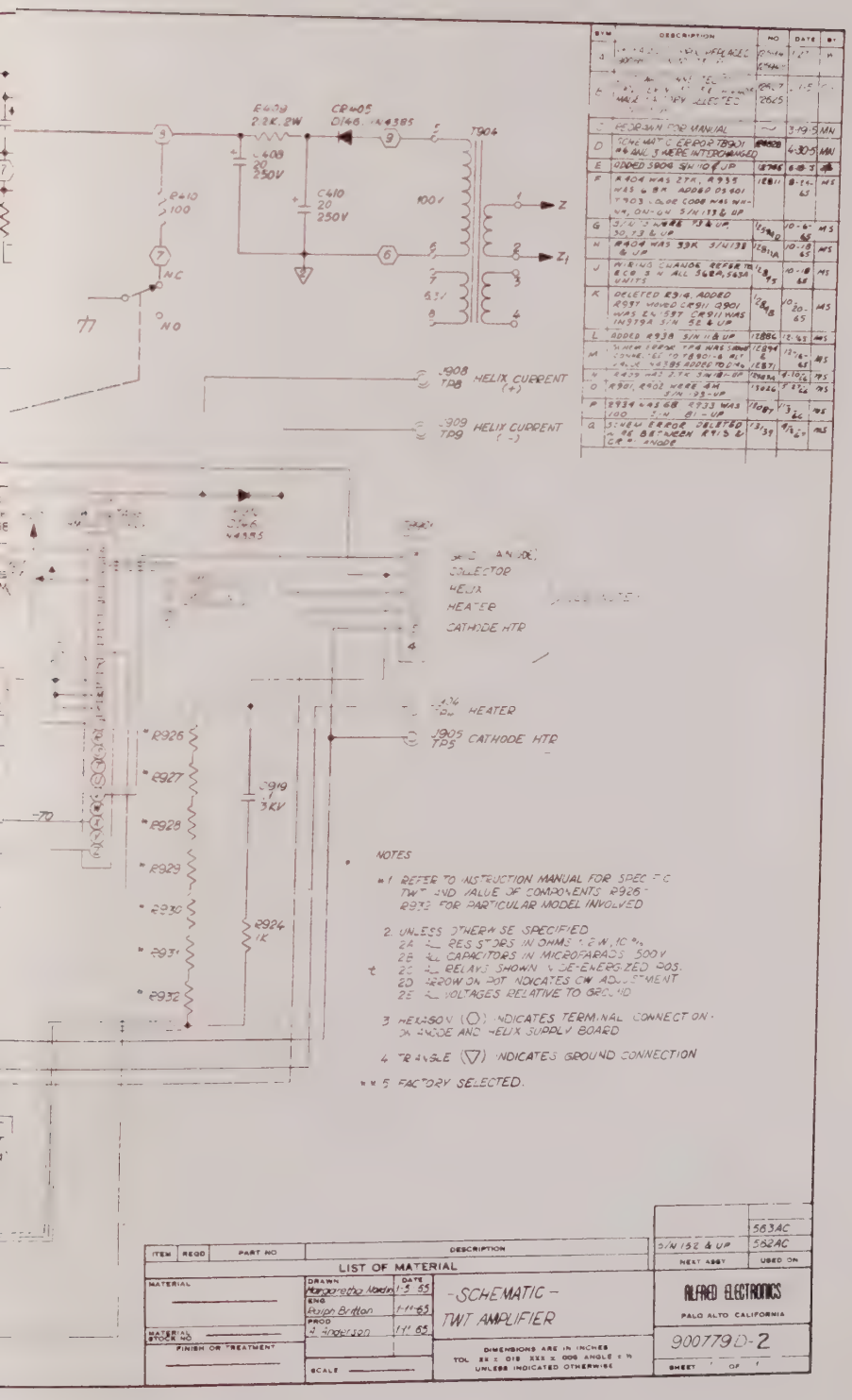
ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

900777D-2

DIMENSIONS ARE IN INCHES
TOL .XX ± .01 .XXX ± .005 ANGLE ± 1°
UNLESS INDICATED OTHERWISE

SHEET 1 OF 1


T901
SEE NOTE 1
CR901A
CR901B
S902
DS902
HV ON
S904
AIR FLOW INTERLOCK
S901
POWER
P901
F901
3A 115V
1.5A 230V
DS901
S903
H.V. INTRLK
K903
6.3V, 90 SEC
(TIME DELAY)
K901
K902
T902
T903
F902
2A SLO-BLOW
V901
0A2
V902
6BH8
V903
7239
Q401
2N699
Q402
2N699
Q901
40251
Q902
2N2147
Q903
2N1540
Q904
2N697
CR402
CR409
CR911
CR912
J200
L.V. SUPPLIES
-70
J901
TP1
+20V
J902
TP2
GND
J903
TP3
-70
GND 2
K904
K905
K906
R904, 62K 2W
R905 1K 1W
R907 1K
R933 27
R934 39
R935 10K
R937 4.7K
R938 1.5
R906 1K



SYM	DESCRIPTION	NO	DATE	BY
C	REDRAWN FOR MANUAL	—	3-19-5	MN
D	SCHEMATIC ERROR TB901 #6 WAS 3 WERE INTRODUCED	[illegible]	4-30-5	MN
E	ADDED S906 S/N 110 & UP	[illegible]	6-8-5	[illegible]
F	R404 WAS 27K, R935 WAS 6.8M ADDED CR401 T903 COLOR CODE WAS WH-VI, OR-GN S/N 173 & UP	[illegible]	8-14-65	MS
G	[illegible] 30, 73 & UP	[illegible]	10-6-65	MS
H	R404 WAS 33K S/N 138 & UP	[illegible]	10-18-65	MS
J	WIRING CHANGE REFER TO ECO # 4 FOR ALL 368A, 563A UNITS	[illegible]	10-18-65	MS
K	DELETED R314. ADDED R937 MOVED CR911, 2901 WAS EA 597 CR911 WAS IN3179A S/N 56 & UP	[illegible]	10-20-65	MS
L	ADDED R938 S/N 11 & UP	[illegible]	12-13	MS
M	SCHEM 1.08MA TP6 WAS SHOWN CONNECTED TO TB901-6 WIRE WAS CORRECTED TO 7	[illegible]	12-16-65	MS
N	R409 WAS 2.7K S/N 18-UP	[illegible]	1-10-66	MS
O	R901, R902 WERE 4M S/N 33-UP	[illegible]	5-12-66	MS
P	R934 WAS 100 S/N 81-UP	[illegible]	7-13-66	MS
Q	SCHEM ERROR DELETED C96 BETWEEN R915 & C9 + ANODE	[illegible]	9-12-66	MS

ITEM	REQD	PART NO	DESCRIPTION
			LIST OF MATERIAL

S/N 132 & UP	563AC
NEXT ASSY	USED ON

MATERIAL	DRAWN Margaretha Hedin	DATE 1-5-65
	ENG Ralph Britton	1-11-65
MATERIAL STOCK NO.	PROD J. Hoover	1-11-65
FINISH OR TREATMENT	SCALE	

-SCHEMATIC-
TWT AMPLIFIER

ALFRED ELECTRONICS
PALO ALTO CALIFORNIA

900779D-2

SHEET 1 OF 1

DIMENSIONS ARE IN INCHES
TOL .XX ± .010 .XXX ± .005 ANGLE ± 1/2°
UNLESS INDICATED OTHERWISE

ENGINEERING NOTES

GENERAL INFORMATION ON TRAVELING-WAVE TUBES

R. A. Huggins*

Engineers who design circuits which use conventional low frequency vacuum tubes usually have at least a speaking acquaintance with their theory of operation. In designing circuits, or in deciding which type of tube to use, careful use is made of the various characteristic curves associated with these tubes. The following discussion will similarly acquaint the applications engineer with the simple theory of the operation of the traveling-wave tube and familarize him with the various characteristic curves which describe its operation.

MICROWAVE AMPLIFICATION

As the microwave region of the radio frequency spectrum came into practical engineering use, devices were needed which could function as better amplifiers and oscillators. Above a few hundred megacycles conventional vacuum tubes no longer amplify properly because the period of one cycle of the radio frequency wave approaches the time it takes the electrons to travel from cathode to anode. As a result the amplification factor of the tube decreases with increasing frequency until no useful gain can be obtained. This is known as the transit time effect.

The first device which served as a practical amplifier above a few hundred megacycles actually made use of the transit time effect. This device, known as a klystron, became useful primarily as an oscillator. The klystron, however, is also capable of acting as an amplifier. Klystron amplifiers are capable of giving high values of amplification, but they have two serious limitations for many applications: They are relatively narrow band devices which usually have no more than a few megacycles bandwidth between half-power points, and tuning the amplifier to different frequencies requires a mechanical adjustment. The klystron is, however, the forerunner of a general class of microwave electron devices which utilize transit time effects in electron beams. This general class of devices includes the traveling-wave tube (TWT).

A klystron is a narrow band device because it involves the use of a very sharply resonant, high-impedance tuned circuit. It is necessary for a klystron to use such a circuit because interaction takes place with the electrons over very short physical distances, and it must develop high electric fields to have efficient interaction with the electrons. It was reasoned, however, that one might obtain a very broadband amplifying device by using a low-impedance, broadband circuit which developed relatively small electric fields that interacted with the electrons over a long physical distance. Such is the basis on which the traveling-wave tube works, and this basic concept led to a wide range of devices which are useful as broadband amplifiers and oscillators in the microwave region.

The traveling-wave tube yields high values

* President, Huggins Laboratories, Inc

of amplification over wide frequency ranges with no mechanical tuning mechanism or variation of any voltages or currents applied to the tube. Power amplification greater than 10,000 (i.e., 40 db gain) over a 2:1 frequency range has been obtained with this type of tube. The actual number of megacycles covered by such tubes can be a staggering figure. For example, an operating bandwidth of 2000 megacycles has been obtained in one typical tube type; 7000 megacycles has been obtained in another.

Tubes can be designed to emphasize various special characteristics. For instance, tubes are built which have low noise properties, high power output, or controlled variations of gain with frequency. Many special tubes are designed and built for particular applications.

FORWARD-WAVE HELIX TYPE AMPLIFIER

Among the simplest circuit elements which satisfy the broadband low-impedance circuit requirement of the traveling-wave tube is a simple helical transmission line. On this so-called helix, the radio frequency energy essentially travels at the velocity of light along the wire from which the helix is wound. Since the wire and the energy follow this helical path, progress of the energy along the axis of the helix is at some fraction of the velocity of light. This velocity is determined by the geometry of the helix (i.e., circumference and pitch) and by the dielectric loading due to the structure which supports the helix. The fields associated with this "slow-wave" extend outward and inward into the region adjacent to the helix, and it is into this region that electrons are sent to interact with the waves.

If electrons are directed along the axis of the helix at essentially the same velocity as the waves, an interaction between the waves and electrons occurs wherein the electrons become bunched. As the electrons progress along the axis they become packed into tighter and tighter bunches. Simultaneously, the radio frequency fields on the helix increase in magnitude as they progress down its length. The increase in energy of this "growing wave" is just balanced by a decrease in the average kinetic energy of the electrons in the beam. In other words, the electrons, on the average, have been slowed down and have given up just enough energy to account for the increasing energy or power level in the waves on the helix.

In practice, the electron beam is formed by an electron gun and focused down the center of the helix to a collector electrode at the farther end (see Figure 1). The electron beam is maintained in a tight pencil beam throughout the length of the tube by the confining forces of a longitudinal magnetic field which surrounds the tube. Electron velocity is determined by the voltage difference between the cathode in the electron gun and the helix, and this voltage difference is ad-

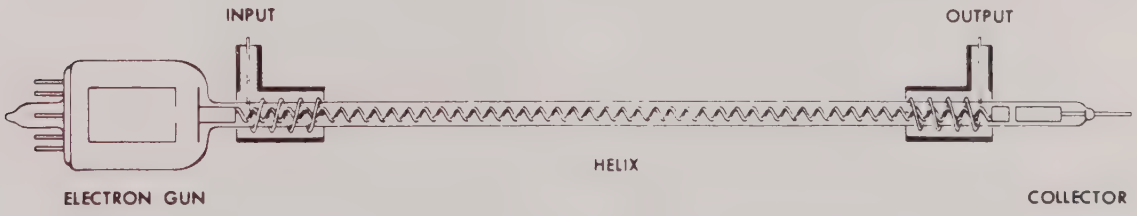


Figure 1. Schematic View of a Traveling-Wave Tube.

justed to give the electrons the right velocity for interaction with the waves. The signal to be amplified is coupled onto the end of the helix nearest the electron gun and propagates along the helix in the same direction as the electron beam. Because of the interaction, the fields on the helix grow exponentially with distance, and these amplified waves are coupled off the helix at the end farthest from the electron gun.

The devices which couple the energy onto and off the helix are special directional couplers which are in themselves helices. These helices are outside the vacuum envelope and are matched to the input and output coaxial transmission lines. This type of coupler is capable of transferring most of the energy from the lines to the main helix, which is inside the vacuum envelope, without making physical contact with the helix. These "coupled helix matches" have the additional advantage of having very wideband transfer characteristic. Further, they are capable of presenting a standing-wave ratio to the coaxial transmission line of 1.5:1 or less.

SPECIFIC CHARACTERISTICS

In the following sections, various characteristic curves that are encountered in traveling-wave tube operation are discussed.

Helix Voltage vs Frequency. A helix is usually designed so that the "slow-waves" travel at a velocity in the range of 1/10 to 1/30 of the velocity of light. If the wave velocity is examined as a function of frequency, it is found that a helix has a general characteristic curve similar to that shown in Figure 2.

In region A, wave velocity varies as a function of frequency; in region B, wave velocity is essentially independent of frequency. A broadband amplifier is normally operated in region B – the "non-dispersive region."

As mentioned before, the electrons must travel at essentially the same velocity as the waves (synchronous velocity) in order to obtain the growing wave interaction. Since the velocity of the wave varies as a function of frequency, the velocity of the electrons must also be varied so that interaction is maintained. Inasmuch as the velocity of the electrons is determined by the voltage difference between the cathode and the helix, there is also a characteristic curve of synchronous helix voltage as a function of frequency (see Figure 2).

FIG. 2

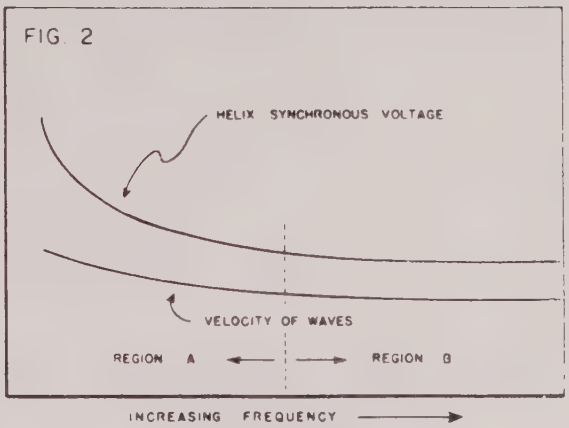


Figure 2. Phase Velocity of the Waves and Synchronous Helix Voltage as a Function of Frequency.

The reason a helix type traveling-wave tube can amplify over wide bandwidths without changing helix voltage can now be easily seen. In the non-dispersive region the synchronous voltage is essentially independent of frequency. That is, the helix voltage which gives the desired interaction between the waves and electrons can be fixed at one value, and this will be the correct value to provide interaction and amplification over a wide range of frequencies.

Gain vs Helix Voltage. To obtain the greatest interaction between the waves and the electrons, and thus the greatest amplification, the helix must be operated at synchronous voltage.

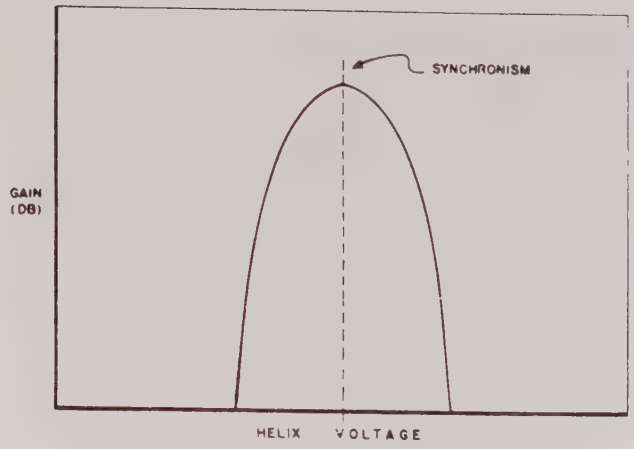


Figure 3. Gain as a Function of Helix Voltage.

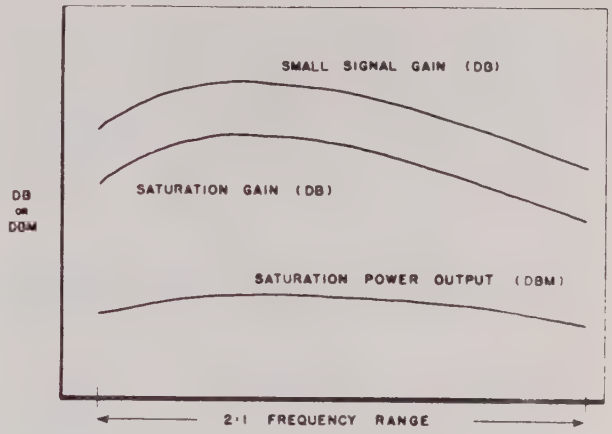


Figure 4. Gain and Power Output as a Function of Frequency.

Should the helix voltage be varied away from synchronism, the gain will decrease as shown by the curve in Figure 3. This characteristic of the TWT is parabolic in shape.

Gain and Power Output vs Frequency. Figure 4 shows a typical plot of gain vs frequency for a fixed value of helix voltage. Small-signal gain is obtained for all values of input signal level except those which drive the tube near its maximum or saturation power output. Saturation gain is the gain obtained when the tube is driven to its saturation power output level. It is seen that the gain and power output curves generally reach a maximum near the center of the band and droop off toward the band edges.

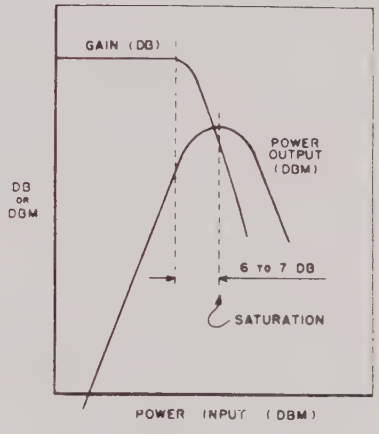


Figure 5. Gain and Power Output vs Power Input at a Fixed Frequency.

Power Output and Gain vs Power Input. Figure 5 shows the variation of power output and gain as a function of power input at a fixed frequency. The amplifier is linear until the power input is within 6 to 7 db of the value which drives the amplifier to saturation. At this point the power output curve begins to droop over, and gain of the tube begins to decrease. At saturation the power output is a maximum, and gain has decreased to the saturation gain level. As the tube is driven beyond saturation the power output drops off, and gain continues to decrease. To obtain maximum power output from an ordinary traveling-wave tube, the right amount of power input must be applied. As will be noted, the saturation region does not exhibit the leveling off or flat saturation characteristic that is found in conventional low frequency amplifier tubes.

Gain vs Beam Current and Grid Voltage. Figure 6 shows that the gain at any fixed frequency is essentially a function of the 1/3 power

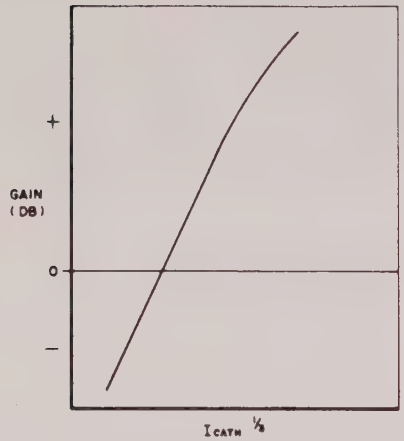


Figure 6. Gain vs Beam Current.

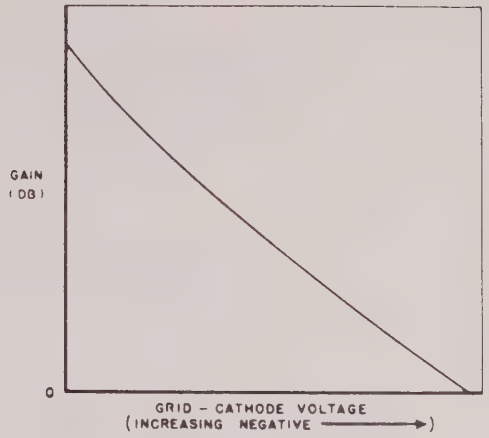


Figure 7. Gain vs Grid Voltage.

of the beam current, and as beam current decreases, gain decreases. Figure 7 shows that the gain of the tube decreases as the grid electrode is made negative with respect to the cathode. This results from the fact that operating the grid negative with respect to the cathode causes the beam current to decrease.

Should the beam current be decreased below a certain value as shown in Figure 6, the gain of the tube measured in db becomes negative, (i.e., the tube is acting as an attenuator). If the beam current is reduced to zero, the net "cold" attenuation of the tube is available. The total change in signal output level as beam current is decreased from its normal value to zero is equal to the sum of the net gain of the tube plus the cold attenuation. This can approach a variation in signal level of about 100 db. Such a change in signal output level is accomplished merely by varying the control grid voltage.

SPECIAL CHARACTERISTICS

Low Noise Amplifiers. A typical low power amplifier may exhibit a noise figure of 20 db. Certain applications require lower noise figures than this. Techniques are available in electron gun design whereby the "shot noise" in the beam can be "de-amplified" before it reaches the beginning of the helix. Special purpose tubes built in this fashion have reached noise figures as low as 6 db.

Narrow Band Amplifiers. Where an application does not require extremely wide bandwidths, tubes can be designed to operate in the dispersive region of the tube characteristic where the velocity of the waves varies as a function of frequency (see Figure 2). In this region, operation at a fixed voltage leads to amplification over only a relatively narrow band of frequencies. Extremely high values of gain (e.g., 60 to 70 db) can be obtained because the problem of controlling spurious oscillations is much simplified since the tube exhibits gain over only a relatively narrow band.

Special Gain Variation. Sometimes special requirements are imposed on the gain variation of the tube as a function of frequency. Tubes can be designed which exhibit an essentially constant value of gain across the band. Others have been built which have linearly increasing gain with frequency. Various other combinations are also possible.

MICROWAVE MEASUREMENT TECHNIQUES[1]

L. A. Roberts *

As traveling-wave tubes come into more common use, the need becomes apparent for clarification of the various measurement techniques involved in evaluating tube characteristics. In such measurements emphasis must be placed upon broad-band, untuned measuring techniques and test equipment since the traveling-wave tube is a very broadband device. Otherwise, much time would be lost in the repetitive and laborious adjustment and tuning of narrow band devices to make point-by-point measurements across wide frequency ranges.

In this Engineering Note we will concern ourselves with the measurement of small-signal gain, power output, standing-wave ratio, insertion loss, and noise figure. Though automatic and more modern techniques may be available, the methods discussed herein will prove both useful and reliable. Further, these methods require commonly available and relatively inexpensive test equipment.

The types of broadband test equipment commonly used are:

1. Self-tracking tunable signal generator with calibrated power output.
2. Untuned coaxial crystal detector.
3. Untuned coaxial bolometer or thermistor mount with self-balancing power bridge.
4. Broadband coaxial fixed attentuator.
5. Coaxial switch (SPDT).
6. Coaxial slotted section (for VSWR measurements) with untuned detector.
7. Coaxial or waveguide directional coupler.
8. Flourescent noise source.

The emphasis on measuring equipment is placed upon coaxial systems. This is because coaxial test equipment has inherently wideband properties. Waveguide equipment is utilized only when equivalent coaxial equipment is not available or will not do an equivalent job.

SMALL-SIGNAL GAIN MEASUREMENT

A rapid and satisfactory method of measuring gain is to make an insertion gain measurement using the substitution method. This method requires no knowledge of the detector characteristics, nor is absolute power calibration of the signal generator necessary. Accuracy of the measurement depends only on the calibration accuracy of the signal generator output attenuator.

Figure 1 shows a block diagram of the small-signal gain measurement system. With the coaxial switches in position 1, the output of the sig-

* Formerly of Huggins Laboratories, Inc.

[1] For a detailed discussion of the latest swept-frequency measurement techniques using the Alfred Electronics Model 3000 7051 Sweep Network Analyzer for direct db or dbm readout over a 60-db dynamic range, refer to Alfred Electronics Application Note 101.

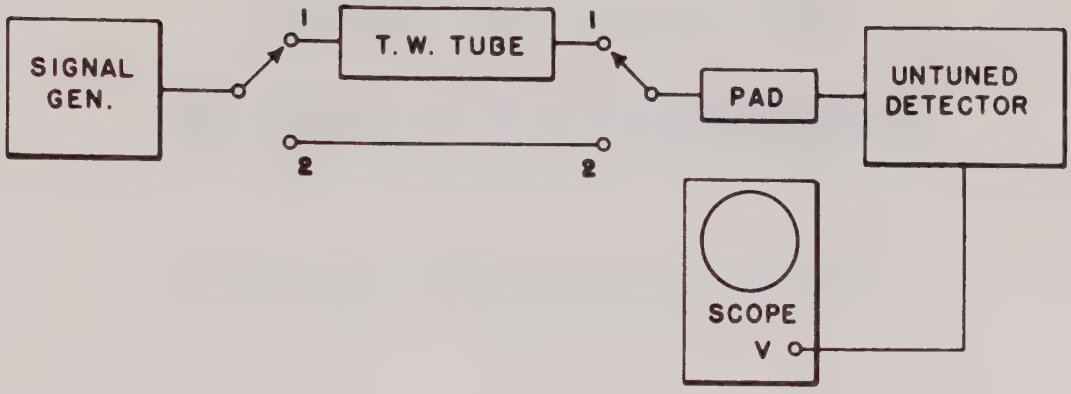


Figure 1. Block Diagram of Gain Measurement System.

nal generator (which has a matched 50 ohm output) is fed to the TWT input through a coaxial single-pole double-throw switch. The output of the TWT is in turn fed through another coaxial switch and a 6 db minimum coaxial fixed attenuator to the untuned detector (If the detector is matched to the coaxial switch, the pad can be eliminated). The detector output is then applied to the vertical deflection channel of an oscilloscope. When the switches are placed in position 2, the tube is by-passed.

Procedure. Apply pulse or square wave modulation to the signal generator. With the tube operating and the switches in position 1, the output attenuator of the signal generator is adjusted to give some convenient deflection on the scope. This is attenuator reading 1. The switches are then placed in position 2 and the attenuator readjusted to give the same deflection on the scope. This is attenuator reading 2. The insertion gain of the tube is then the difference between attenuator readings 1 and 2 measured in db.

Precautions. Both the signal generator and the detector must present good impedance matches as seen by the switch. If they are not matched, reflection losses can give up to several db error in gain. This is the reason for the pad ahead of the unmatched detector, for a 6 db pad guarantees a VSWR of at most 1.5:1.

Also, the switches used must have a low VSWR and very low crosstalk. Crosstalk is stray feedthrough from the input to output terminals of the DPST switch combination through the unused channel. The crosstalk ratio is measured with the TWT removed and is equal to the difference between the signal generator attenuator readings when it is adjusted for equal scope deflection with the switches in position 1 and 2. Regenerative feedback around the switches, which introduces errors in the gain measurement, will be prevented if the crosstalk ratio is at least 20 db greater than the gain of the tube being measured. If the crosstalk ratio exceeds 45 db, it probably cannot be measured with the system in Figure 1. The crosstalk ratio can be measured in such cases with the insertion loss measurement system soon to be described.

Further, care must be taken to insure that the output power level of the tube is at least 10 db below the saturation power level. This eliminates errors due to the decreasing gain characteristic of the traveling-wave tube in the region near saturation.

POWER OUTPUT MEASUREMENT

When making power measurements over wide frequency ranges, it is convenient to use broad-

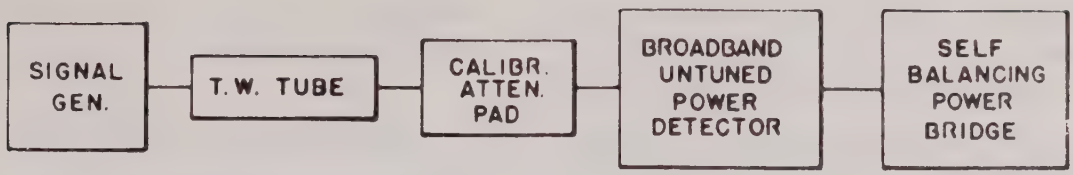


Figure 2. Block Diagram of Power Measuring System.

band (untuned) bolometer or thermistor mounts as power detectors. When these mounts are operated in conjunction with a self-balancing wattmeter bridge, they provide a convenient system for the measurement of absolute power.

If the power level to be measured is greater than the maximum allowable power input to the mount, a calibrated attenuator pad should be inserted ahead of the mount. The most convenient type of pad to use is the resistive film type which has attenuation characteristics that are essentially independent of frequency. Care must be taken not to exceed the maximum input rating of the attenuator.

If power levels to be measured are greater than the rated dissipation of standard attenuator pads, a directional coupler must be placed on the output of the tube. The main arm of the coupler is terminated with a broadband load, and the power detector, with appropriate pads, is placed in the auxiliary arm of the coupler. Broadband coaxial directional couplers with coupling ratios of 10 and 20 db from main arm to auxiliary arm are available.

Should gain measurements be made in conjunction with the power measurements, the power output of the signal generator must be calibrated using its power monitor at each frequency. For accuracy, the power output reading of the signal generator should be initially checked using the bolometer mount and the wattmeter bridge at least over the range of power levels that the bridge can accurately read. Small-signal gain measurements obtained with this equipment should check with the small-signal gain measurements made by the substitution method if the calibration of the attenuator pad and the signal generator is checked.

If all power measurements are recorded in terms of dbm (i.e., db with respect to one milliwatt), the readings of the power bridge, the attenuator (in db) and the signal generator need be merely added and subtracted to obtain power output and gain. Conveniently, most signal generators and power bridges are calibrated in dbm as well as milliwatts.

Figure 2 shows the block diagram of the power measurement system. The power output is given by the equation:

$$\text{Pout (dbm)} = \text{Pad Attenuation (db)} + \text{Ratio of Directional Coupler (db)} + \text{Power Bridge Reading (dbm)}$$

The gain of the tube is given by the equation:

$$\text{Gain (db)} = \text{Pout (dbm)} - \text{Pin from Signal Generator (dbm)}$$

The above gain measurement is valid for both small-signal gain and gain measured in the saturation region and beyond.

STANDING-WAVE RATIO OR REFLECTION COEFFICIENT MEASUREMENT

For direct measurement of voltage standing-wave ratio (VSWR), the coaxial slotted line is the

simplest method. It is essential to have an untuned detector on the slotted line, however, in order to speed up broadband measurements.

When it is necessary to examine the VSWR continuously over a wide frequency range, and where fast checks are required such as on production test setups, the slotted line type of measurement becomes prohibitively time consuming and laborious.

For such situations, the measurement of reflection coefficient through the use of directional couplers is recommended. Two directional couplers which are connected so that one gives an output proportional to the incident wave and the other an output proportional to the reflected wave from the load are used. These two outputs can be detected and compared with a ratiometer to give a direct reading of reflection coefficient. The reflection coefficient is then converted to equivalent VSWR if necessary. The greater the accuracy required in the measurement of reflection coefficient, the higher must be the directivity of the directional couplers. In waveguide, directivity greater than 40 db over the waveguide range can be obtained which allows measurement of reflection coefficient of 0.1 with an accuracy of ±.02. This means that a load VSWR of 1.2 will give an indicated reading between 1.15 and 1.25. A waveguide to coaxial transition can be used to adapt the reflectometer to coaxial systems, but residual reflection in the transition limits the accuracy at low VSWRs.

Once the initial calibration is performed in such a reflectometer system, it is only necessary to tune the signal generator across the frequency range and read the reflection coefficient values directly. An excellent detailed discussion of this method, its errors and limitations, is given in the Hewlett-Packard Journal, Volume 6, Number 1-2, Sept. - Oct., 1954.

Even faster measurements can be made when a swept oscillator is employed. Reflection coefficient can be displayed directly on a scope as a function of frequency, and the measurement can be made at a glance.

INSERTION LOSS MEASUREMENT

Measurement of insertion loss in the range of 40 to 100 db (e.g., cold loss measurement in a traveling-wave tube) over a wide range of frequencies is not uncommon. Such a measurement cannot be made with a 1 milliwatt signal generator and a broadband detector, for this type of system does not have the power levels, nor the sensitivity, to measure much more than 45 db insertion loss.

Wideband measurements can be made quickly and easily, however, with the use of one or two traveling-wave tubes as amplifiers. Use of a traveling-wave tube with a noise figure of 20 db ahead of the detector gives a sensitivity into a broadband detector on the order of −65 to −75 dbm. This alone allows insertion loss measurements of 65 to 75 db. Further, if the output of the signal generator is amplified to the power level of one watt (+ 30 dbm) by using a medium power traveling-wave tube, the total insertion loss then measurable becomes 95 to 105 db.

Since traveling-wave tubes are broadband, untuned devices, the only adjustment necessary in this system as frequency is changed across the band is the tuning of the signal generator. The insertion loss measurement is made in the same manner as the insertion gain measurement shown in Figure 1 except for the addition of the amplifiers before and after the switches. Commercially available switches, when connected as shown in Figure 1, have been measured which have a combined crosstalk ratio in excess of 120 db This, of course, eliminates any crosstalk error in insertion loss measurements in the range of 95 to 105 db.

NOISE FIGURE MEASUREMENT

When one is interested in measuring noise

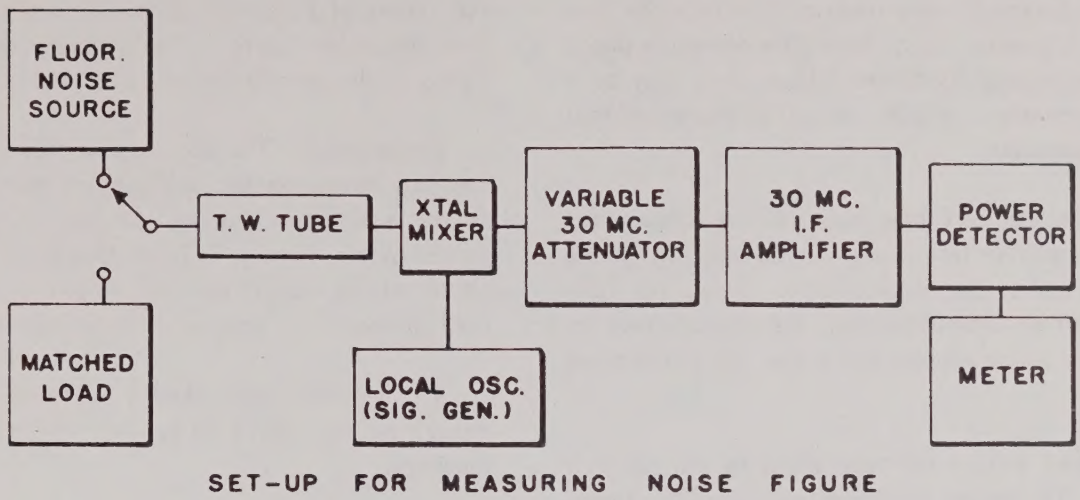


Figure 3. System for Measuring Noise Figure.

figure at a number of frequencies over a wide frequency band, a system which employs a fluorescent tube noise source and a superheterodyne receiver with a square-law second detector (i.e., a power detector) can be used. If noise figure does not vary too rapidly with frequency, a simple receiver can be used which employs an untuned crystal mixer, a local oscillator, a 30 mc IF strip, and a power detector. Note that no preselection or mixer tuning is used.

Without a preselector, the receiver will respond equally well to both the signal and image frequencies. With a 30 mc IF amplifier, these two frequencies will be only 60 mc apart. The measured noise figure will be an average of the true values at two frequencies 60 mc apart providing noise figure is not a rapid function of frequency. This is accurate enough for most purposes. If noise figure varies so rapidly that it will be appreciably different at two frequencies spaced 60 mc apart, then preselection is necessary.

The noise figure of an amplifier is defined as the ratio of the signal-to-noise ratio at the input of the amplifier to the signal-to-noise ratio at the output of the amplifier, That is,

$$F = \frac{(S/N)in}{(S/N)out} \qquad \text{(power ratio)}$$

When the measurement is made according to the method to be outlined, and a noise source whose level is 15.8 db above thermal noise is used, the above equation becomes:

$$F = \frac{37k}{\frac{P_1}{P_2} - 1} \qquad \text{(power ratio)} \qquad (1)$$

where, P_1 and P_2 are as defined in the measurement procedure below, and k, a number smaller than 1.0, is the cable loss in db between the noise source and the tube converted to a power ratio. (e.g.) for cable loss = 1db, k = .794)

When a fluorescent noise source is used, it is not necessary to know the effective RF noise bandwidth of the receiver.

Procedure: The tube to be measured is connected into the system shown in Figure 3. The

power detector in the receiver may take the form of a bolometer or a thermistor operating into a self-balancing wattmeter bridge, or it may be a thermocouple whose output is connected to a microammeter.

With the TWT operating and the local oscillator tuned to the desired frequency, switch the tube input to the noise source. Adjust the variable 30 mc attenuator until the output meter indicates approximately full scale. This is reading P_1.

Then switch the tube input to the matched load. The output meter now indicates P_2. Insert the values of P_1 and P_2 in equation 1 and compute the noise figure. To determine the noise figure in db, merely convert this number to db.

Precautions: The accuracy of this measurement is based on the assumption that the receiver is linear. This will be true if the local oscillator signal is large enough to produce linear mixing and if the IF amplifier is operated in the linear portion of its characteristics

The measurements should be taken quickly enough so that power meter drift will not affect readings.